NEW ENGLAND INTERCOLLEGIATE
GEOLOGICAL CONFERENCE

GUIDEBOOK

57th ANNUAL MEETING

October 8 - 10, 1965

AT

BOWDOIN COLLEGE
BRUNSWICK, MAINE

NEW ENGLAND INTERCOLLEGIATE GEOLOGICAL CONFERENCE

Guidebook to Field Trips in

Southern Maine

Arthur M. Hussey II,
Editor

57th Annual Meeting
October 8-10, 1965

held at

Bowdoin College
Brunswick, Maine

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LEADERS:

Harold W. Borns, Jr.	Professor of Geology, University Maine
Marc W. Bodine, Jr.	Professor of Geology, Harpur College
Dabney W. Caldwell	Professor of Geology, Wellesley College
Roy W. Farnsworth	Professor of Geology, Bates College
Frank Perham	West Paris, Maine
John Hogan	Geologist, Black Hawk Mining Co.
D. J. Hagar	Professor of Geology, Univ. Mass.
Richard A. Gilman	Professor of Geology, Fredonia State College
Arthur M. Hussey II	Professor of Geology, Bowdoin College
Robert G. Doyle	State Geologist, Augusta, Maine
Lester Greenwood	Geologist, Black Hawk Mining Co.
Kost A. Pankiwskyj	Professor of Geology, Univ. of Hawaii
Jeffrey Warner	Harvard University, Dept. of Geology

EDITOR AND CONFERENCE ORGANIZER
Arthur M. Hussey II

NEIGC MEETINGS, 1965, BRUNSWICK, MAINE

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INTRODUCTION

In organizing the field trips for the 57th Annual Meeting of the New England Intercollegiate Geological Conference an attempt has been made to present a variety of field trips appealing to many different geological specialities. Five of the field trips deal principally with the stratigraphy and structure of the metamorphic rocks of southern Maine and reflect detailed work undertaken in recent years in anticipation of or as a direct result of compilation of a new geologic map of the state. The intensive work in the area during the past 8 years has resulted in a fairly thorough understanding of the rock types, stratigraphy, and structure of the metamorphic belt of southern Maine, and correlations of stratigraphic units to the fossiliferous sequence already known in the Waterville area (Perkins and Smith, 1925, Osberg, in press) gives us now a much firmer understanding of the age relations of the rocks throughout the area. It is anticipated that the new map of the state will be available early in 1966, and these trips will afford the participants a first hand glance at the geology of some of the areas where concentrated effort has been made. It is hoped that participants will have a fuller understanding and appreciation of the general relations which will be shown on the map, and of the efforts that have gone into the compilation.

Two trips deal with surficial geological relations which have been the subject of recent investigations. In deciding what areas to include, our principal aim has been to select those areas which have not been visited in the past few years--to present fresh geology. In consequence of this, one of the two trips involves considerable travel and assembly at a point (Waterville) 50 miles from the Conference headquarters in Brunswick. It is hoped that the newness of the geology to be seen and the very interesting geological relations to be examined will be more than adequate compensation for the greater distance that has to be traveled to and from the field trip area.

One trip affords the opportunity to examine and discuss the relations of the small complex funnel intrusion of gabbro, the Cape Neddick Complex, at York Beach, Maine. Superb exposures permit detailed examination of the relations of the units of the complex, and the different types of layering within the units. Also to be examined are the relative age relations of three spacially close igneous rock suites--the gabbroic complex, alkaline felsic intrusives of the Agamenticus Complex, and the diabase dikes which are very common in the surrounding metasediments.

Of interest to mineralogists will be the trip to four currently operated pegmatite quarries in the vicinity of Greenwood, Maine. Included is the famous Harvard Mine.

Finally, since Blue Hill, Maine is the center of the newest major mining operation in the northern Appalachians, and the first significant metal mining operation in Maine's history, it is highly appropriate to include a visit to this property during this Intercollegiate Conference. At the time of this writing it is not known whether underground facilities can be visited, but surface facilities and equipment and local geology will be examined.

I wish to thank James Stacy Coles, President of Bowdoin College, for permission to invite the Conference to this campus, and for his continuing interest in the preparations for the Conference. To the field trip leaders Harold W. Borns, Jr., University of Maine, Orono, Maine; Richard A. Gilman, College of the State University, Fredonia, New York; Marc W. Bodine, Harpur College, Binghampton, New York; Robert G. Doyle, State Geologist of Maine; Dabney W. Caldwell, Wellesley College, Wellesley, Mass.; Frank Perham, West Paris, Maine; Roy W. Farnsworth, Bates College, Lewiston, Maine; D. J. Hagar, University of Massachusetts, Amherst, Massachusetts; Kost A. Pankiwskyj, University of Hawaii, Honolulu, Hawaii; Jeffrey Warner, Harvard University, Cambridge, Mass.; and Lester Greenwood and John Hogan, Black Hawk Mining Company, Blue Hill, Maine; go my sincerest thanks for the effort they have put into the preparation and leadership of their respective field trips.

I wish to thank Stanley Perham for his kind offer to allow participants to visit active quarries presently being operated by him. I am grateful to the management of Black Hawk Mining Company for their permission to visit the mining facilities at the Blue Hill Property.

Donovan Lancaster, Director of the Bowdoin College Moulton Union, and Orman Hines, Manager of Food Services, have given considerable of their time and advice in the planning and operation of the many administrative facets of a conference such as this one. The guidebook stencils were typed by Mrs. Pamalee Labbe, Departmental Secretary. The effort of these people on behalf of the 57th Annual Meeting of the New England Intercollegiate Geological Conference is gratefully acknowledged.

Professor John Rodgers of Yale University has given most welcomed advice during all stages of preparation for the Conference. For this and his assistance in mailing the announcements, I wish to express my thanks. I am grateful to James Skehan, S. J., Boston College, who so kindly shared with me some of the secrets of success of the 56th Conference last year, and

pointed out some organizational pitfalls to avoid.

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TRIP A

Geology of the Orrs Island 7 1/2' Quadrangle and Adjacent Area

Leader: Arthur M. Hussey II, Department of Geology,
Bowdoin College.

INTRODUCTION

The Orrs Island 7 1/2' quadrangle, comprising the SW 1/4 of the Bath 15' quadrangle, is underlain by metasediments and metavolcanics intruded by syntectonic binary granites and pegmatites and infrequent post-tectonic basalt and diabase dikes. Figure 1 is a preliminary geologic map of the quadrangle representing field mapping during the summers of 1963, 1964, and 1965. Figure 2, a generalized geologic columnar section for the area summarizes the lithologic character of the stratigraphic units. Fuller descriptions of some of these units will be presented under discussions of individual field trip stops.

These rocks represent high grade equivalents of the Casco Bay Group typically exposed in the Cape Elizabeth-Scarboro-South Portland area (See Trip F, this Conference). Pelites in the Orrs Island quadrangle indicate metamorphism to the staurolite and sillimanite grades. The sillimanite isograd is shown on Figure 1. Quartz veins in very aluminous pelites contain masses of clear pink andalusite which is partially replaced by sillimanite in a zone roughly one-half to one mile wide on the staurolite side of the isograd. Andalusite generally does not persist on the sillimanite side of the isograde. The isograd is drawn on the basis of appearance of the sillimanite in the schists and not on its appearance in quartz veins.

As a result of mapping in the quadrangle it has been necessary to recognize a new formation embracing the rocks exposed on Sebascodegan Island. For convenience of discussion, this sequence of rocks is referred to as the "Sebascodegan" Formation in this guidebook, and is composed of the lithologies described in the Columnar Section. Formal establishment of this as a formation must appear elsewhere. This formation is at least in part equivalent to the Cushing Volcanics of the Casco Bay-South Portland area, but it includes several lithologies not represented in the Cushing. That portion of the "Sebascodegan" Formation most closely related to the Cushing is the sequence of volcanics designated "sev" in the vicinity of Lookout Point, Harpswell Neck.

Among the more conspicuous units of the "Sebascodegan" Formation are the numerous amphibolites, both massive, and thin, well-bedded. These will be discussed in greater detail in the field trip stop discussions.

The other units recognized in the quadrangle can be correlated with the formations of the Casco Bay Group--the Cape Elizabeth Formation, Spring Point Greenstone, Scarboro Formation, Spurwink Limestone and Jewell Formation--as originally defined by F. J. Katz (1917) and mapped by the writer in the Portland quadrangle, and by Bodine in the Casco Bay quadrangle (see Trip F, this Conference). The Diamond Island, a thin unit consisting of black siliceous graphitic phyllite, is not present in the Orrs Island quadrangle.

The major folds in the quadrangle are the Harpswell Sound syncline on the west and the Hen Cove anticline on the east. Drag folds with axial plane schistosity are common, especially in the Cape Elizabeth Formation, and in general bear out the major structures. Locally a second set of crude small scale folds involving both bedding and schistosity is developed. Plunges of the primary drags are rather variable indicating frequent reversals of the major plunge direction.

Lineations are well-developed in all units of the quadrangle, but especially so in the Cape Elizabeth Formation. In this unit three lineations can commonly be seen. On the bedding surfaces of the competent beds a lineation formed by the intersection of a fracture cleavage and bedding, parallel to the plunge direction of primary fold axes, is frequently present and gives these beds a rather woody appearance. The second and third lineations are observed in the micaceous beds and are formed by the close crenulation of schistosity. The principal crenulation has axes plunging consistently to the northeast about 25 to 30 . The lesser crenulation plunges essentially down dip of the general schistosity.

Along the western shore of Harpswell Neck, local relations suggest the presence of a major fault: 1) south of Jordan Point, the sea-cliff is held up by very rusty schist and granulite of the "Sebascodegan" Formation dipping very gently eastward and striking parallel to the shore. At the waters edge is an exposure of aluminous schist much like the "ces" unit of the Cape Elizabeth Formation, but with a strike nearly at right angles to the shoreline; 2) at different points along the shore, thin breccias and minor faults are present; 3) the "serg" unit is offset about 3/4 mile between Scrag Island and the mainland. These three observations argue

Figure 1. Preliminary geologic map of the Orrs Island 7 1/2' Quadrangle. Explanation of symbols on opposite page.

EXPLANATION OF SYMBOLS

j -- Jewell Formation

sc -- Scarboro Formation

sp -- Spring Point Greenstone

ce -- Cape Elizabeth Formation
    ces -- staurolitic rusty weathering member

se -- "Sebascodegan" Formation *
    ser -- rusty schist member
    serg -- rusty garnet-rich biotite-quartz schist.
    seam -- massive amphibolite
    seab -- bedded amphibolite
    sev -- felsic volcanics (equivalent of the Cushing Fm.)

*Unofficial name, used here informally.

Geologic contact

Geologic contact underwater

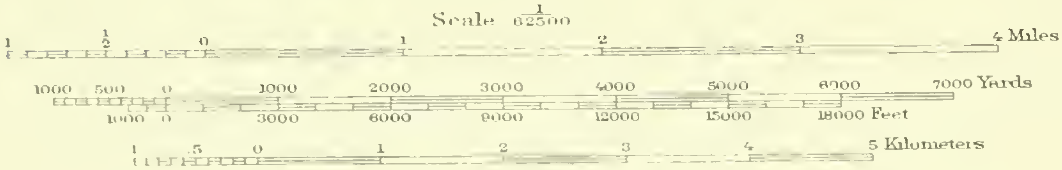
Metamorphic isograd

Approximately located fault

Trace of anticlinal axis

Trace of synclinal axis

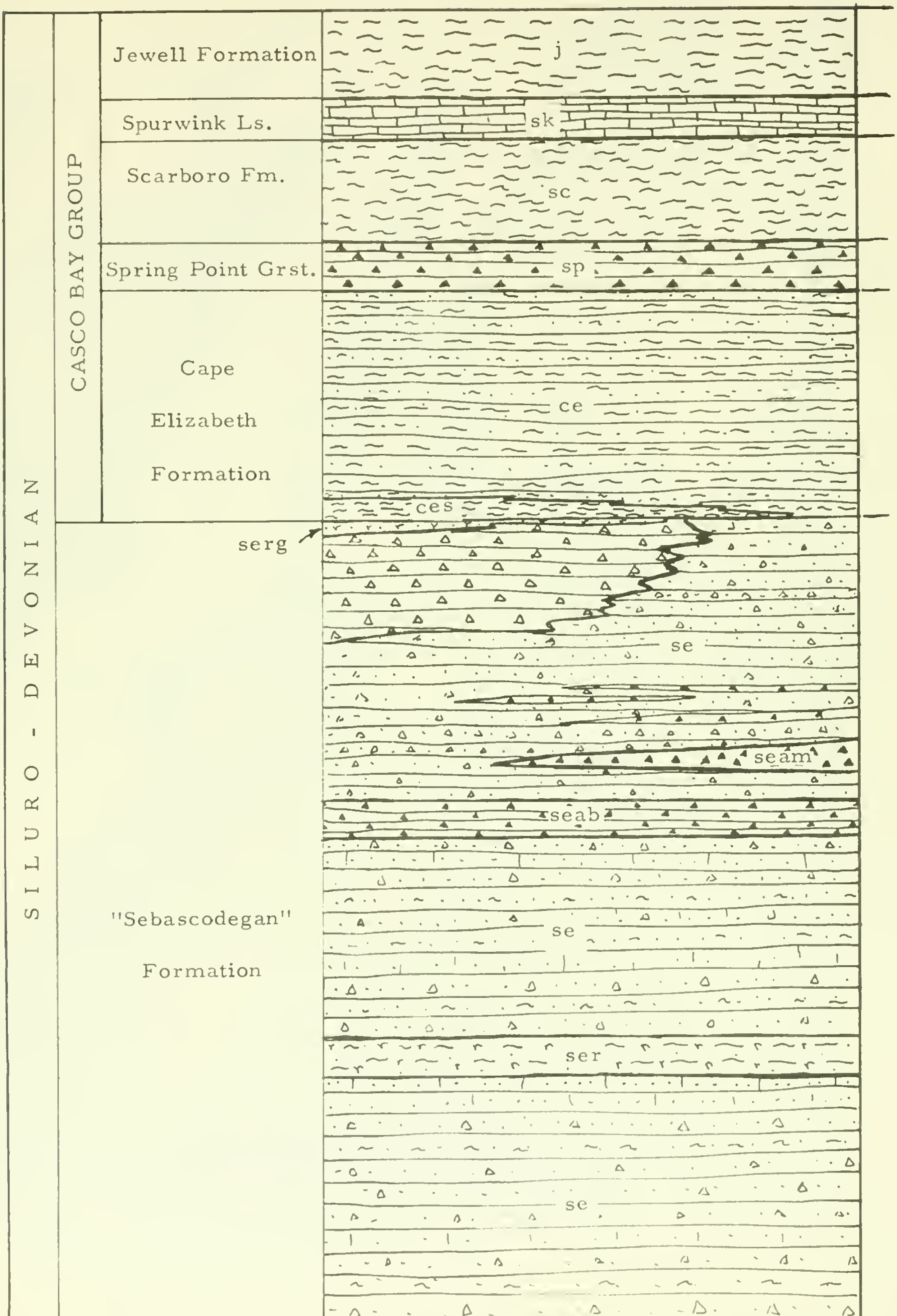
Scale $\frac{1}{62500}$



Contour interval 20 feet

Datum is mean sea level

Preliminary Columnar Section, Orrs Island 7 1/2' Quadrangle



	General lithologic character
	Rusty-weathering biotite-muscovite garnet schist with minor thin interbeds of micaceous quartzite and amphibolite.
	Thin-bedded gray limestone with biotite schist/phyllite interbeds.
	Same as the Jewell Formation
	Thin bedded amphibolite ± garnet, and quartzo-feldspathic granulites.
	ce: Thin-bedded biotite and biotite-muscovite quartzite, quartz-muscovite-biotite schist, and muscovite-biotite-garnet-quartz-staurolite or sillimanite schist, with sparse quartz-plagioclase-garnet-hornblende granulite pods and lenses. Beds of amphibolite up to 6 feet thick rendered discontinuous by pinching and swelling are present locally. ces: Poorly bedded rusty-weathering staurolitic two mica schist.
	se: quartz-feldspar-biotite granulite, quartz-feldspar-biotite-hornblende granulite, with minor calc-silicate granulite, quartz-plagioclase-biotite-sillimanite granulite, and biotite quartzite. serg: very rusty-weathering sulfidic garnet quartzite to garnet-biotite schist. sev: thin crudely bedded plagioclase-quartz-biotite ± garnet gneiss; plagioclase-quartz-muscovite schist. Metamorphic equivalents of felsic tuffs and agglomerates. seam: massiv coarse-grained hornblende plagioclase amphibolite. seab: thin to medium-bedded amphibolite with thin interbeds of biotite schist, calc-silicate granulite, and thin seams of diopsidic marble; includes a unit up to 6 feet thick varying from pure calcite marble to diopside-hornblende-marble. ser: rusty-weathering quartz- muscovite-biotite schist and quartz-feldspathic granulite

strongly for a fault extending through Middle Bay and just striking the shore of Harpswell Neck south of Jordan Point. This is essentially on a line with a fault mapped by Bodine (see Trip F) in the Casco Bay quadrangle and by the writer in the Portland quadrangle. It is proposed that the fault in the Orrs Island quadrangle is a continuation of the one in the Portland and Casco Bay quadrangles. The attitude and age of the fault are not known, but the southeast side is the upthrown side.

In the Cape Elizabeth Formation in the western part of the quadrangle minor vertical sinistral shears are very common and are the latest of all structures noted. Bedding is dragged around consistently in a left-handed fashion, and in some places parted by minor slippage. These shear zones strike essentially east-west. Although individual offsets either by bending or faulting are not more than a few feet (most are less than one foot), these zones are frequent enough to cause significant deflection of general strike. At one point near Ewin Narrows (separates Harpswell Neck from the upper part of Sebascodegan Island) where a single bed can be followed about 400 feet, the local strike and general trend vary about 20 . This is significant when attempting to predict the outcrop zone of a given unit along strike. These shears are apparently later than diabase and basalt dike emplacement. On Orrs Island one small diabase dike has been slightly deformed by one of them.

Pegmatites are very abundant on Mere Point Neck; along the crestal zone of the Hen Cove anticline (an interesting case of structural control of pegmatization); and along the western edge of the quadrangle. The pegmatites are concordant lenses in these zones, becoming cross-cutting stringers away from these centers, and finally cross-cutting dikes with even, straight, matched walls farthest from these pegmatization centers. Some of the pegmatites grade into binary granite. The mineralogy of all pegmatites examined is simple and non-exotic, consisting of quartz and orthoclase, sometimes in graphic intergrowths, and biotite and muscovite micas, with occasional black tourmaline.

Correlation and Age

Reconnaissance mapping by the writer in other parts of the Bath quadrangle and in the Wiscasset and Gardiner quadrangles has indicated that the Cape Elizabeth Formation is equivalent to the interbedded quartzites and pelites at Coopers Mills (see Trip B, this Conference). This correlation is made starting with the Cape Elizabeth exposures on the east limb of Hen Cove anticline, and carrying them through extremely migmatized pelites

in the Bath-Woolich-Wiscasset-Alna area to non-migmatized or slightly migmatized pelites and quartzites exposed in the road cut along Route 17 just southwest of Coopers Mills. By similar reconnaissance mapping the "Sebascodegan" Formation has been carried through into the Wiscasset and Gardiner quadrangles, and lies on either side of the Coopers Mills rocks (see Trip B).

In the Freeport and Brunswick area the "Sebascodegan" Formation is underlain by a thin unit consisting of very rusty weathering granulite and schist traceable to the rusty rocks exposed along U. S. Route 201 at Iron Hill in Gardiner. Beneath these rusties lies a thick sequence of quartz-biotite-feldspar and lime-silicate granulites equivalent to the Berwick Formation (Hussey, 1962) and Vassalboro Formation (Osberg, in press). These granulites are excellently exposed in Interstate 95 roadcuts between Brunswick and Freeport. Bodine (Trip F) refers to these rocks as the Pejepscot Formation following Fisher (1937), but the writer does not fully concur with this useage. Fisher included in the Pejepscot Formation rocks which are equivalent to part of the "Sebascodegan" Formation, but his mapping did not extend to the area of Sebascodegan Island. If the term "Pejepscot" is to be retained in the regional stratigraphic nomenclature, the writer would prefer to see it raised to the status of a Group. The Pejepscot Group would include the Berwick Formation (in this area), the rusty granulites and schists of Iron Hill, and the "Sebascodegan" Formation discussed here. Overtop the Pejepscot Group is the Casco Bay Group.

Katz (1917) originally referred to the Casco Bay Groups being of Carboniferous age. He considered the Group to be equivalent to the Eliot Formation of southwestern Maine and adjacent New Hampshire. The Eliot Formation was correlated with the Worcester phyllite in Massachusetts which was regarded as being of Carboniferous age on the basis of alleged fossils. Billings (1956) has critically reviewed these correlations pointing out errors in interpretation, and has suggested that a Silurian age is a better determination for the Berwick and Eliot Formations (the Eliot Formation lies immediately below the Berwick).

Present investigations show that the Casco Bay Group lies above the Berwick Formation, and is therefore younger, not older, than that Formation. The most meaningful information on the age of these rocks comes from the Vassalboro-Waterbille area. In that region, fossils of Llandovery age occur in the Mayflower Hill Formation, and of Wenlockian age in the Waterville Formation. Our mapping shows that the Waterville Formation is correlable with the Eliot Formation. Osberg (in press)

assigns a Siluro-Devonian age to the Vassalboro Formation above the Waterville. This is taken as the age of the Berwick Formation. The "Sebascodegan" Formation and Casco Bay Group are younger still by superposition and may be Siluro-Devonian or straight Devonian in age.

The Cape Elizabeth Formation and possibly other formations of the Casco Bay Group are equivalent to the Gonic, Rindgemere, and Towow Formations (Littleton equivalents) of southern York County and the Newfield-Kezar Falls area (See Trip H, this Conference). In these areas, the "Sebascodegan" Formation is absent.

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Quadrangle Maps Needed

Orrs Island 7 1/2' quadrangle
Bailey Island 7 1/2' quadrangle
Small Point 7 1/2' quadrangle
South Harpswell 7 1/2' quadrangle

Assembly Point

In front of Cleaveland Hall, Bowdoin Campus

Time

Trip will leave by bus at 8:00 A. M. sharp!

Road Log

Mileage

0.0	Bowdoin Campus at West Campus Gate. Turn right onto Bath Road.
0.3	Pass Bowdoin Pines.
2.1	Entrance to Brunswick Naval Air Station, right.
2.2	Right turn onto Route 24.
4.5	Exposures of amphibolite and marble along the highway for about 1/2 mile. We will return to these at stop #4.
5.9	Cross the Gurnet
6.6	Road to Cundys Harbor left.
10.5	Bear slight left onto tar road off Route 24.
12.0	Stop #1. "Sebascodegan" Formation. Amphibolites and Associated Granulites.

Park opposite house with name "Young" on mailbox. Walk eastward down lane to shore. Examine the rocks along the shore, southward around the point and into the cove on the west side of the point, and as far down Long Point shore

as time permits. See detailed geologic map of this area (Figure 2).

The rocks of this area lie on the western flank of the Hen Cove anticline centered through the Bethel Point - Yarmouth Island area. Rock types include massive, fine to coarse-grained hornblende amphibolites, some bedded hornblende amphibolites with biotite schist and calc-silicate granulite interbeds, quartz-plagioclase-biotite-(hornblende)-(garnet) granulites, quartz-feldspar-diopside-hornblende granulites, and rusty quartzo-feldspathic granulites and schists. Thin beds or groups of beds of light-gray plagioclase cummingtonite amphibolite are relatively common in the quartzo-feldspathic granulites. The rock units to be seen will not be described in detail here. However, the following notes refer to specific areas along the walk and are located on the detailed map of this area.

Note 1: Rocks at the end of the woods lane, along the shore, are quartzo-feldspathic granulites of medium gray color with 1/2 to 2" long lens-shaped pods of lighter granulite probably representing fragments of felsic volcanics.

Note 2: Thick massive amphibolite with coarse poikiloblastic texture. Mineralogy rather simple--essentially hornblende and plagioclase (An_{30-35}) with accessory apatite and opaques. Probably andesitic flows or dioritic sills before metamorphism.

Note 3: Sequence here consists of distinctly bedded quartzo-feldspathic granulites with minor light gray fibrous amphibolites and biotite quartzite and schist. The amphibolites are composed of plagioclase (about An_{30}) and cummingtonite (optically positive, highly twinned, light brown color, n_B about 1.651, inclined extinction), with minor amounts of biotite and opaques. The quartzo-feldspathic granulites probably represent immaturely weathered sediments derived from volcanic terrains, and the cummingtonite amphibolites, beds of magnesium-rich volcanic tuff.

Note 4: Associated quartzo-feldspathic granulites and calc-silicate granulites, very thin and well bedded.

Note 5: Massive, fine-grained, weakly laminated hornblende-biolite amphibolite.

Note 6: At the western contact of the rusty granulite and schist with amphibolite and calc-silicate granulite "drag" folds all have sinistral pattern, but varying plunges, giving opposing interpretations of major structure. The drag folds in the Cape Elizabeth Formation on Gun Point to the west consistently indicate a major anticline to the east. If the contact between the Cape Elizabeth and "Sebascodegan" Formations is conformable (as has been assumed so far), and there is no complication due to faulting, the sequence at this stop must top to the west; consequently the minor folds seen here plunging northward must not reflect the traditional drag mechanism of formation. Furthermore, the distribution of rock types precludes tight, major isoclinal folding within the sequence examined here.

Return to the buses via the dirt road.

Turn around and return to Route 24.

14.4 Sharp left turn onto Route 24. From here to the Bailey Island Bridge, all outcrops are of the Cape Elizabeth Formation.

15.2 Causeway to Orrs Island.

18.3 Cross granite crib bridge to Bailey Island. Outcrops on the west side of the bridge at the Orrs Island end are of the Spring Point Greenstone whereas those on the east are of the Cape Elizabeth Formation. Here the Cape Elizabeth Formation contains occasional boudined dark green beds of amphibolite.

19.4 Bailey Island Post Office on the right.

19.5 Right turn onto tar road.

19.6 Stop #2. Spring Point - Cape Elizabeth Contact.

Park in Skillings Boat Yard and walk to the shore beside the Boat Yard office.

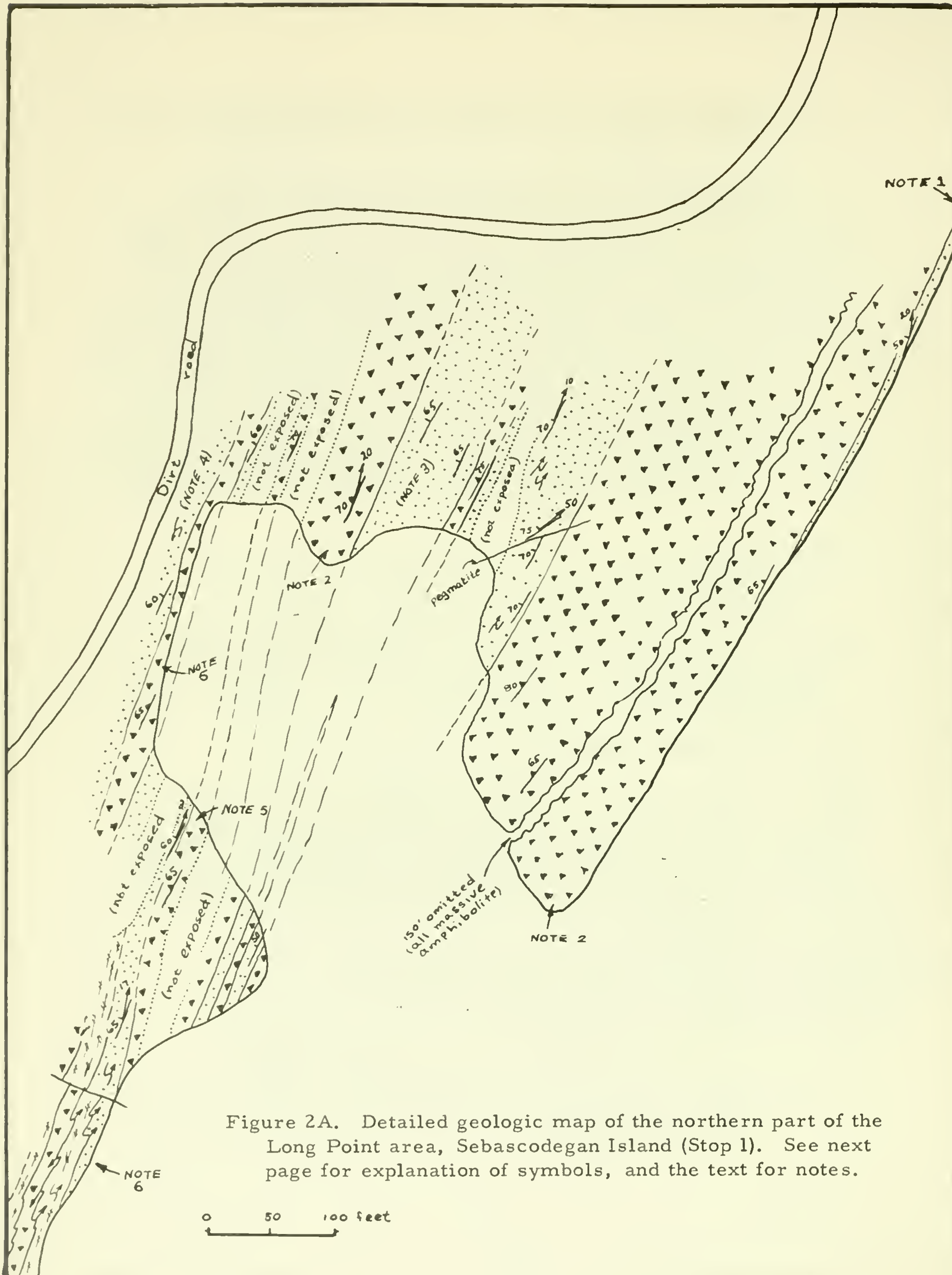

Figure 2A. Detailed geologic map of the northern part of the Long Point area, Sebascodegan Island (Stop 1). See next page for explanation of symbols, and the text for notes.

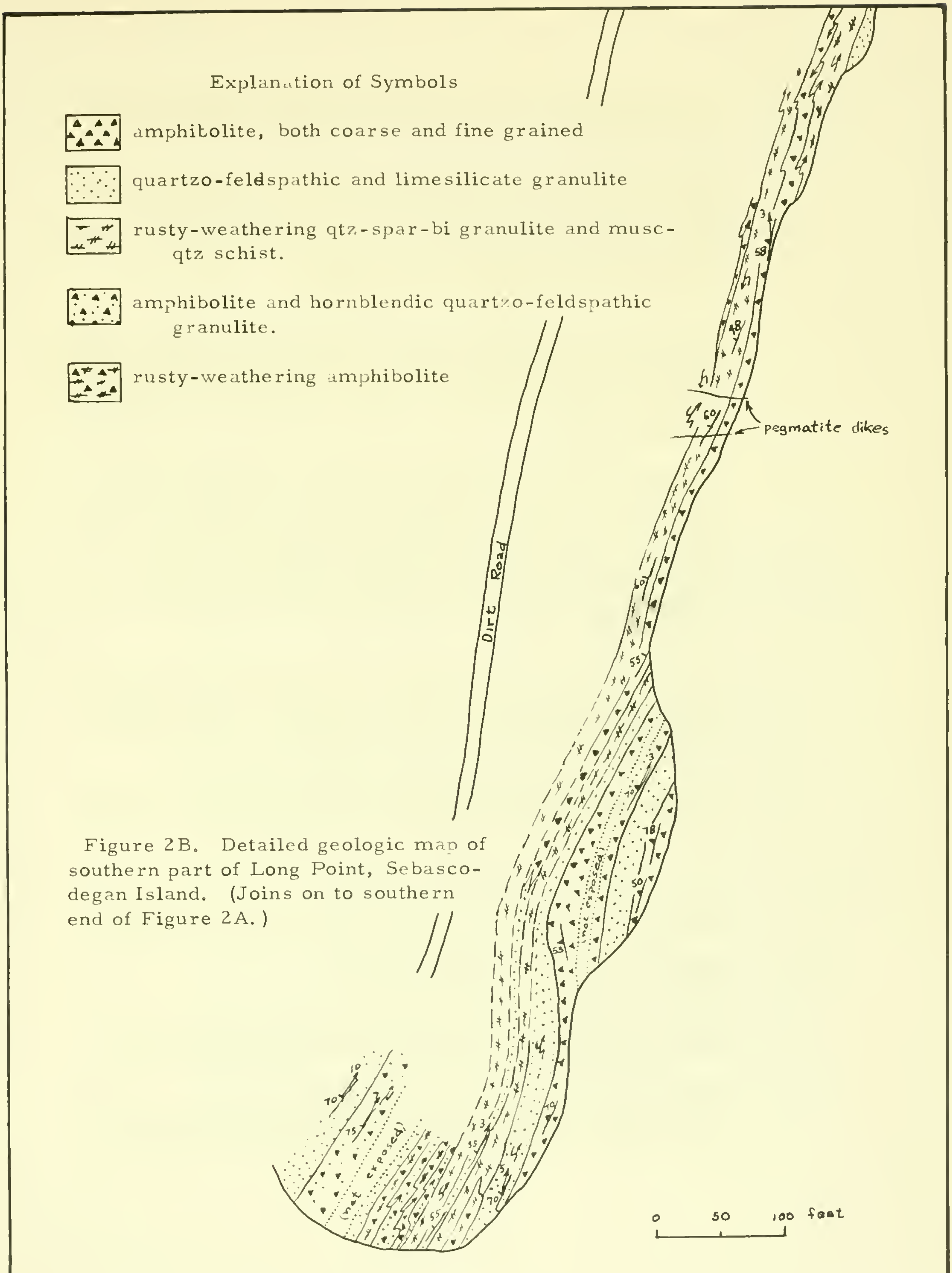

Figure 2B. Detailed geologic map of southern part of Long Point, Sebascodegan Island. (Joins on to southern end of Figure 2A.)

The outcrops here are on the eastern limb of the Harpswell Sound syncline.

The contact between the Cape Elizabeth Fm. and the Spring Point Greenstone is located beside the Boat Yard office, concealed by only an interval less than two feet wide. Bedding planes in both formations are conformable. Figure 3 is a detailed map of relations at this point.

The Cape Elizabeth Fm. here consists of thin, rather weakly bedded quartz-muscovite-biotite schist with prominent chlorite and garnet porphyroblasts. More aluminous beds to the south and north, both, indicate the staurolite grade of regional metamorphism.

The Spring Point Greenstone consists of a series of thin garnet amphibolites, feldspathic biotite-muscovite quartzite, biotite-garnet schist, medium greenish-gray chloritic schist with needles of a light green amphibole (actinolite?), and quartz-feldspar-garnet-biotite granulite. Before metamorphism, these were probably basic volcanic tuffs and feldspathic sandstones.

Outcrops on the western limb of the structure on Harpswell Neck expose higher portions of the formation which appear to be less amphibolitic and more feldspathic, some portions of which may represent metamorphosed felsic tuffs.

Primary drag folds in the general area all indicate that tops are to the northwest on this side of the structure.

Turn around and return to Route 24.

19.7 Right turn on Route 24. Proceed to the end of the highway.

21.0 Stop #3. Cape Elizabeth Formation.

Park cars at the end of the highway. Examine the outcrops on the east shore just beyond the gift shop and snack bar.

Outcrops here are of typical Cape Elizabeth Fm., consisting of thinly interbedded micaceous quartzite, and two-mica quartz schist. Ledges on the other side of the cobble beach

expose the same lithology plus some interunits of somewhat rusty weathering staurolitic two-mica schist. Quartz veins in the latter carry sparing amounts of pink andalusite which has been partially altered to sillimanite and white mica. Andalusite and sillimanite, both, are absent from quartz veins in the non-staurolitic quartzites and schists; also, sillimanite does not occur in the schists themselves.

Turn around and return along Route 24.

23.6 Bailey Island crib bridge again.

30.8 to 31.3 Outcrops of well-bedded amphibolite.

34.6 Stop #4. "Sebascodegan" Formation.

Park in parking area on west side of road at the crest of the hill. Walk back (south) to outcrop of marble and associated amphibolite on the east side of the road. CAUTION: WATCH OUT FOR FAST MOVING TRAFFIC. SOME PEOPLE THINK THIS IS A DRAG STRIP!

Good exposure of marble bed about 5 feet thick composed of pure calcite. Marble is interbedded with thinly laminated (bedded?) amphibolite and some calc-silicate granulite. At top of hill beside parking area is a quarry about 15 feet wide and 700-800 feet long where the marble was obtained for agricultural purposes around the turn of the century.

After examining these exposures proceed on foot about 800 feet north along Route 24, past the parking area, to long roadcut of bedded amphibolite on the west side of the highway. These are dark green hornblende amphibolites with interbeds of phlogopitic biotite schist and calc-silicate granulite. Some beds contain cummingtonite and possibly anthophyllite-gedrite. The plagioclase in these bedded amphibolites is markedly more calcic (An_{50-70}) than the plagioclase of the massive amphibolites. This plus the close association with marble and calc-silicates is suggestive of a sedimentary parent for the bedded amphibolites.

Continue on Route 24 northward.

36.6 Left onto Bath Road (old U.S. 1)

37.2 Outcrop of rusty-weathering Cape Elizabeth in railroad cut on the right.

38.9 Left onto Route 123.

39.0 Stop #5. Lunch.

Park near the entrance to Cleaveland Hall and Gymnasium parking lots. Lunch will be under the pines.

Continue on Route 123.

46.0 Outcrops of typical Cape Elizabeth Formation.

47.4 Stop #6. Cape Elizabeth Formation. Rusty staurolite schist member.

Park beside Bailey's Grocery Store. Walk about 500 feet westward down dirt road to Navy fuel pipeline. Observe outcrops south along pipeline clearing for about 200 or 300 feet.

Exposures of the somewhat rusty weathering staurolitic unit at the base of the Cape Elizabeth Formation--two-mica garnet-staurolite schist and schistose quartzite. Numerous quartz veins cutting the schist carry clear pink andalusite somewhat altered to sillimanite and white mica. As at stop #3, andalusite and sillimanite occur only in the quartz veins, and not in the schist. Furthermore, andalusite and sillimanite are not present in the quartz veins of the normal quartzose Cape Elizabeth exposed just east of the pipeline, clearly indicating that the quartz veins are of very localized origin.

This aluminous member of the Cape Elizabeth is recognized only on this limb of the Harpswell Sound syncline.

Continue on Route 123.

48.0 Well-lineated Cape Elizabeth on right.

48.9 Left onto dirt road, and bear right 300 feet east.

49.2 Bear right.

49.5 Left turn to shore area.

49.6 Stop #7. Spring Point Greenstone.

This stop is on the western limb of the Harpswell Sound syncline. Here, some of the same units of the Spring Point Greenstone as exposed at stop #2 are seen again. The Cape Elizabeth Fm. is exposed 100 feet west across a narrow inlet.

Return to Route 123.

50.5 Left turn onto Route 123.

53.6 Stop #8. Spurwink Limestone and Jewell Formation.

Park in Estes Beach and Lobster House parking area. Walk north to the exposures of the Spurwink Limestone on the western shore of the Neck, then walk south to exposures of the Jewell Formation at end of causeway on east side of highway.

The outcrop of thin-bedded gray limestone with biotite schist and dark hornblendic amphibolite on the west shore north of the parking lot are correlated with the Spurwink "ribbon" limestone of the Casco Bay Group named by Katz (1917) and mapped by Bodine (see Trip F, this Conference) in the Casco Bay quadrangle and this writer in the Portland quadrangle.

On the east shore of the Neck just south of the parking lot, two similar units of "ribbon" limestone are exposed close to roadside and may represent part of the same unit as seen to the north. These limestones are overlain to the west by garnet-rich rusty and non-rusty schists assigned to the Jewell Formation. Similar schists comprise the Scarboro Formation on the other side and stratigraphically below the Spurwink Limestone. Drag folds in some inter-bedded amphibolites indicate tops to the southeast. This locality is close to the center of the Harpswell Sound syncline.

The metamorphic grade here may be the garnet zone (no staurolite noted here).

Turn around. Return on Route 123.

58.4 Pass Bailey's Store. Be ready for left turn.

58.6 Left onto Lookout Point Road. Go to the end of the road.

59.3 Stop #9. "Sebascodegan" Formation. Felsic volcanics and associated rocks.

The outcrops to be examined are located along the tip of Lookout Point and on the two small islands beside the Point. Figure 4 is a detailed map of this locality.

The rocks exposed here include quartz-plagioclase (An_{15-20})-biotite granulite and gneiss, quartz-plagioclase-muscovite-biotite (sparing) schist, dark gray rusty-weathering garnet-rich biotite quartzite, and somewhat rusty muscovite-biotite schist. The first two lithologies quite clearly represent felsic meta-volcanics, and in the quartz-plagioclase-biotite granulite and gneiss are numerous elongated blocks or lenses of light and dark granulites suggestive of agglomeratic character.

Note the fine drag fold in the garnet-rich quartzite on the island closer to Lookout Point, indicating a minor syncline to the southeast. A similar dark gray garnetiferous quartzite is exposed south of the fishing wharf on the east side of the cove, and probably marks the other limb of the syncline.

In the granulites on Lookout Point, note the laminated boudins, well-developed in the rocks east of the rusty schist.

The units here are correlated with the Cushing metavolcanics as mapped by Bodine (see Trip F, this Conference).

Turn around and return to Route 123.

50.9 Left turn onto Route 123.

68.1 Left onto College Road.

68.3 Right onto Campus Drive through east gate.

68.5 Front of Cleaveland Hall. END OF TRIP.

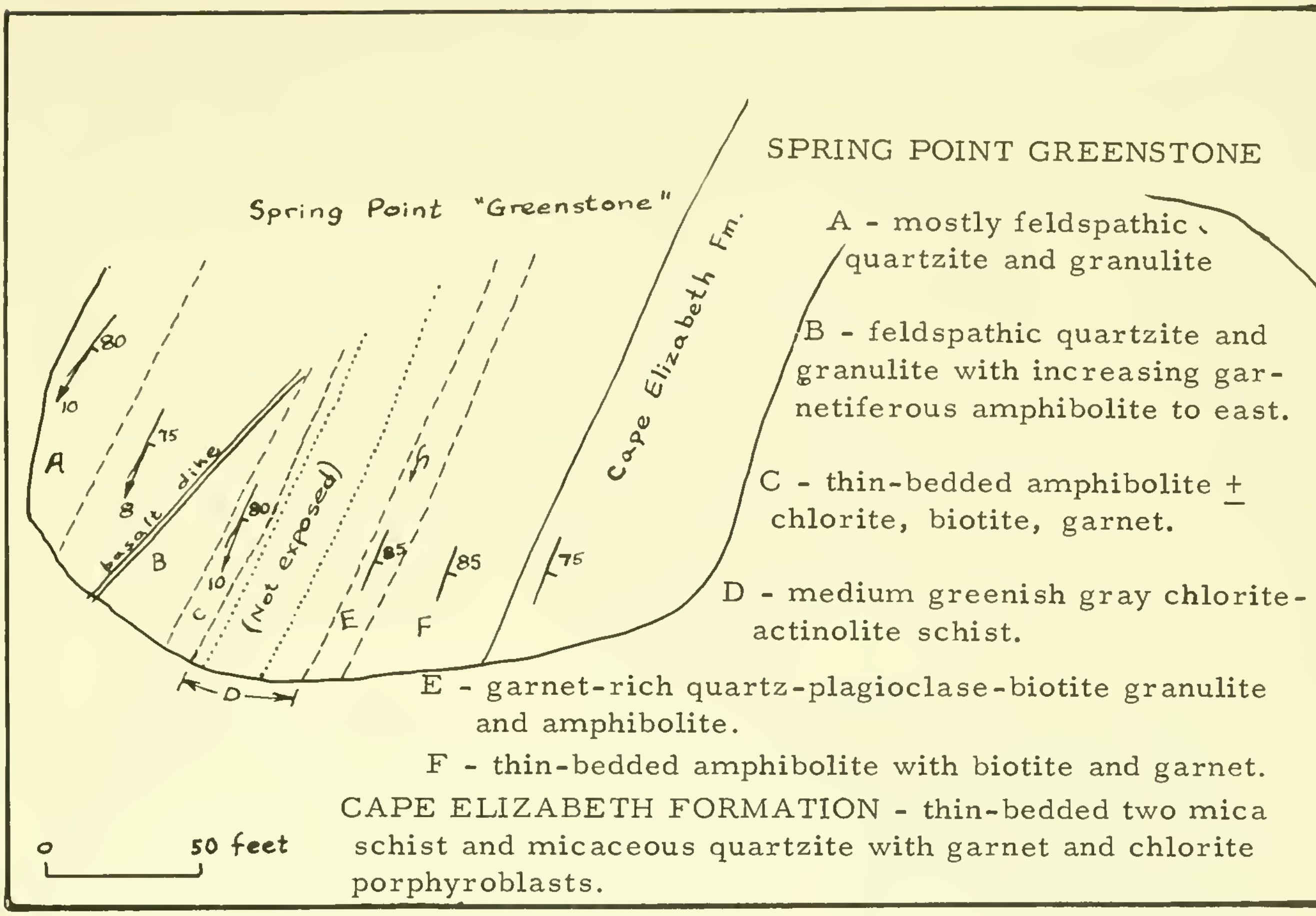

Figure 3. Detailed geologic map for Stop 2, Bailey Island, Maine

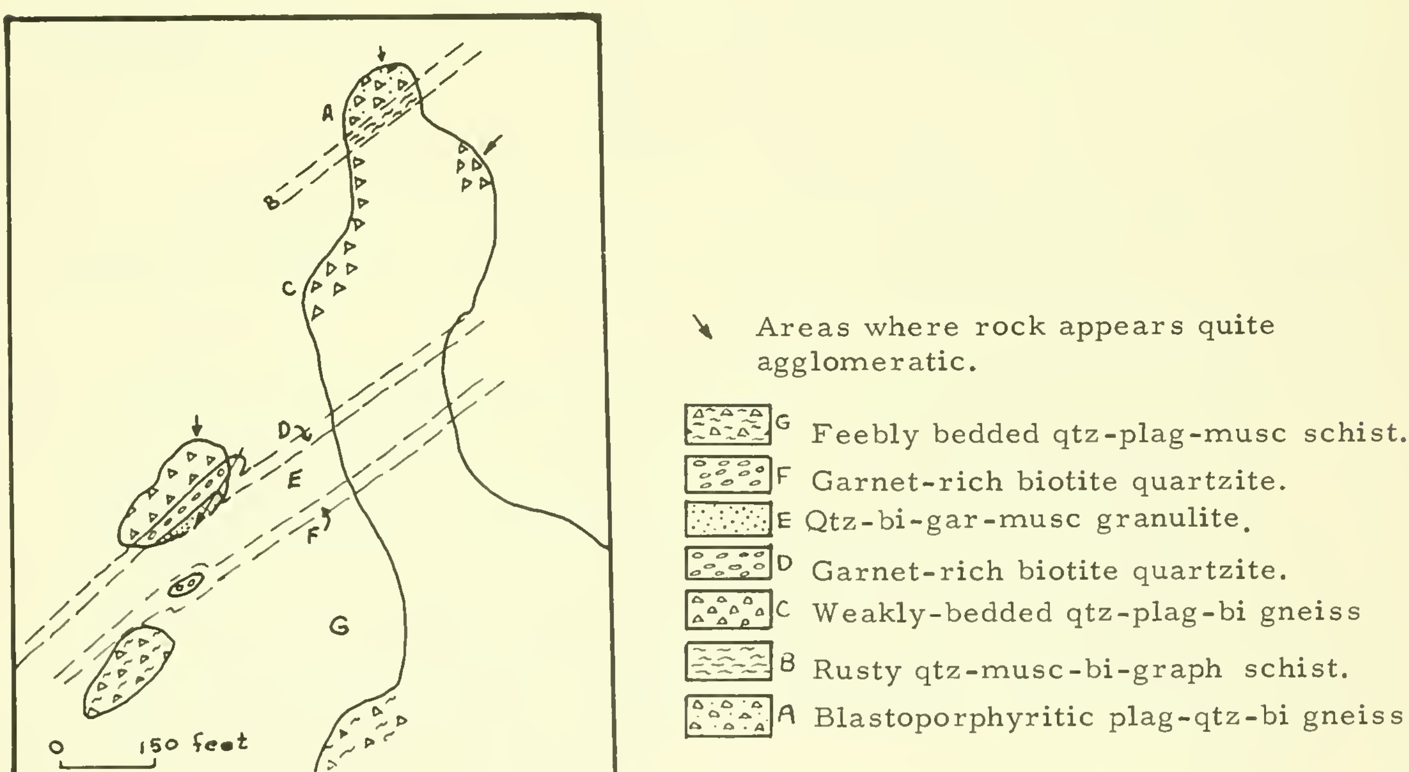

Figure 4. Detailed geologic map of the Lookout Point area, Harpswell Neck, Maine (Stop 9).

TRIP B

PALEOZOIC SECTION ACROSS CENTRAL MAINE

Leaders:

Robert G. Doyle, State Geologist
Maine Geological Survey

Jeffry Warner, Maine Geological Survey &
Harvard University

INTRODUCTION

This trip will study the stratigraphy in a 45 mile wide belt through the major synclinorium in South-Central Maine. The rocks are all high grade metamorphics; starting with the Wenlockian (Middle Silurian) pelites and interbedded limestone 10 miles northeast of Lewiston, traversing eastward into the Devonian (?) interbedded pelites and quartzites at Coopers Mills, and continuing east back down section to the pelites and interbedded limestones at Appleton and Union.

The synclinorium is overturned with its axial plane dipping to the northwest. There are many structural complications in the Lewiston Quadrangle, related, at least in part to the 40 mile wide Sebago pluton. A geologic map is included in Figure 1.

Stratigraphy

A stratigraphic column is included as Table 1. Many stratigraphic names that are not as yet published are used in a casual manner as a matter of convenience.

Sabattus Formation. This unit is composed of sillimanite-muscovite-biotite-garnet schist with beds and lenses of two mica-feldspar-quartz schist and other lenses of quartzite. Beds, 1 to 5 cm. thick, of calc-silicate granulite are scattered throughout this unit. In the low and medium grades of metamorphism (in the Augusta Quadrangle) this unit has interbedded thin quartzite layers (1 to 15 mm.). The pelite layers are 2 to 10 times as thick. The quartzites display a complicated set of internal laminations; very few tops can be read from these laminations. In the sillimanite zone the unit typically has knots of sillimanite, in places attaining the size of 1 cm. The Sabbatus Formation is 3000 - 7000 feet thick, based on the exposed section at Sabattus Mountain.

Limestones - The limestones are 40 - 300 feet thick zones of ribbon-rocks, i. e., they are composed of interbedded calcareous and slatey beds. The lime beds are 1 - 7 cm. thick, whereas the slate beds are only 1/2 to 1/10 as thick. The calcareous beds are diopside or actinolite marbles, or calc-silicate granulites. The slate beds are biotite-quartz granulites.

Table 1

Stratigraphic Column for South-Central Maine

Age	Northwest Flank	Southeast Flank
	Coopers Mills Formation*	Coopers Mills Formation*
Devonian or Silurian	Volcanics*	
	Iron Hill Formation*	
	Vassalboro Formation	Quartzites
		Lincoln Sill
Silurian	Sabattus Formation	Penobscot Formation
	Limestones	Limestone

The Sabattus Formation, with its limestones is traced directly into the fossiliferous Waterville Formation of Osberg (in preparation). Based on lithologic similarity the Sabattus Formation is also correlated with the Eliot Formation and its limestone (Hussey, 1962) and the Buckfield Group (Warner and Pankiwskyj, this guidebook). The Sabattus Formation is considered Wenlockian (Middle Silurian), the age of the fossils in the Waterville Formation.

Penobscot Formation. This unit, named by Baston (1908) is an undifferentiated package of metamorphosed clastic sediments plus several limestone

*Unpublished names used informally for convenience of discussion and reference.

zones. The unit contains rusty- and gray-weathering pelites and quartzites. The upper part of the unit is a chiastolite and/or staurolite schist. At lower grades it is a crinkled phyllite. The limestone zones are actinolite or diopside marbles. Based on lithologic similarity and the symmetry of the section, at least the upper part of the Penobscot Formation is correlated with the Sabattus Formation. The lower part of the Penobscot Formation may be Ordovician.

Vassalboro Formation. This unit is composed of thin to thick bedded (2 meter thick beds have been observed) biotitic, feldspathic and calcareous quartzites. The beds are graded in several places. The upper part of the unit is characterized by quartz-feldspar-biotite$\pm$actinolite granulite. This "salt and pepper" rock includes much of Fisher's Pejepscot Formation (1941). Many of the biotitic quartzites contain the biotite in thin (1 mm.) laminea. Scattered through the formation are beds (1 to 5 cm. thick) of pelite. Thin beds of limestone have also been observed. Many beds and stringers of calc-silicate are found. They are from 1 to 10 cm. thick, and may make up 30 percent of a given outcrop. The unit's thickness is difficult to establish since there is a great variation in areal outcrop distribution. A presumed thickness of at least 10,000 feet is suggested.

Tops evidence on the northwest contact of the Vassalboro Formation has been found by Osberg (in preparation) in the Waterville region. He finds graded-bedding topping into the Vassalboro. The Vassalboro is thus assigned a Post-Wenlock age.

The Vassalboro Formation is correlated with the Berwick Formation of Hussey (1962). The Vassalboro has been traced northeast into the Bucksport Formation of Trefethen (1950) where it turns around the nose of the syncline. It has been further traced into the quartzites on the southeast limb of syncline we are studying.

Quartzites. This unit is composed of calcareous and biotitic quartzites. It is correlated with the Vassalboro Formation as stated above. It may be traced south to the ocean at Pemaquid.

Lincoln Sill. This unit has been studied by Trefethen (1937). He calls it a porphyritic syenite.

Iron Hill Formation. This unit is highly sulfidic "with minor graphite" pelite and quartzite. It weathers a deep rusty color and is an excellent marker horizon. It is between 200 and 500 feet thick, and is found at the Vassalboro - volcanics boundary.

Volcanics. This unit is composed of a complex of zones of three rock types: 1. amphibolite 2. feldspar granulite and 3. quartzite. The amphibolites are hornblende$\pm$feldspar$\pm$garnet granulites. The feldspar granulites are feldspar-biotite-quartz granulites with beds and stringers of amphibolite. The quartzites are biotite quartzites with thin interbeds of muscovite. The quartzites contain zones of two-mica schist. The volcanic unit has a thickness of 200 to 800 feet.

The volcanics lie over the Vassalboro Formation or its equivalents and under the Coopers Mills Formation. They pinch or facies out to the northeast. On the northwest limb of the syncline, the volcanics are traced south into the "Sebascodegan" Formation of Hussey (Trip A, this guidebook), and the Cushing Volcanics of Bodine (Trip F, this guidebook). It is not clear whether the volcanics are a facies of the underlying quartzites or the overlying pelites. The non-volcanic portion is quartzitic in most places, but Coopers Mills type pelite is observed interbedded with the volcanics in several outcrops.

Coopers Mills Formation. This unit forms the core of the syncline. It is composed of interbedded two-mica schist and biotite quartzite. Bedding is on the scale of 1 to 4 cm. Several zones of the unit are mostly quartzite and many others are mostly pelite. The quartzites are distinct in texture from the Vassalboro quartzites in that they are not calcareous or laminated. Since the top of the Coopers Mills is never exposed, only a minimum thickness may be estimated - 3500 to 4500 feet.

The Coopers Mills Formation has been traced south into the Cape Elizabeth Formation of the Casco Bay Group (Hussey, Trip A, this guidebook). The Coopers Mills has also been traced northeast into the Knox Gneiss of Perkins and Smith (1925) and Trefethen (1950). The Knox Geniss is a dark, fine-grained quartzite with 1 mm. thick muscovite partings that are 2 - 10 mm. apart.

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Road Log

Meet at 0800 hours, Saturday, October 9, 1965.

Topographic maps needed: Gardiner, Lewiston, Liberty, Vassalboro, Waldoboro, and Wiscasset.

0.0 Road log starts at the Main Gate of Bowdoin College at Sills Hall. Go 1/2 block east to traffic light, turn left onto Federal Street.

0.6 Stop sign, turn left for one block, then right onto Maine Street. Cross Interstate 95 and cross bridge over Androscoggin River on U. S. 201. You are now on Main Street in Topsham.

1.3 Left turn onto Me. 196.

2.5 Crops from here to Lisbon Falls are salt and pepper rocks of the Vassalboro Formation and pegmatite.

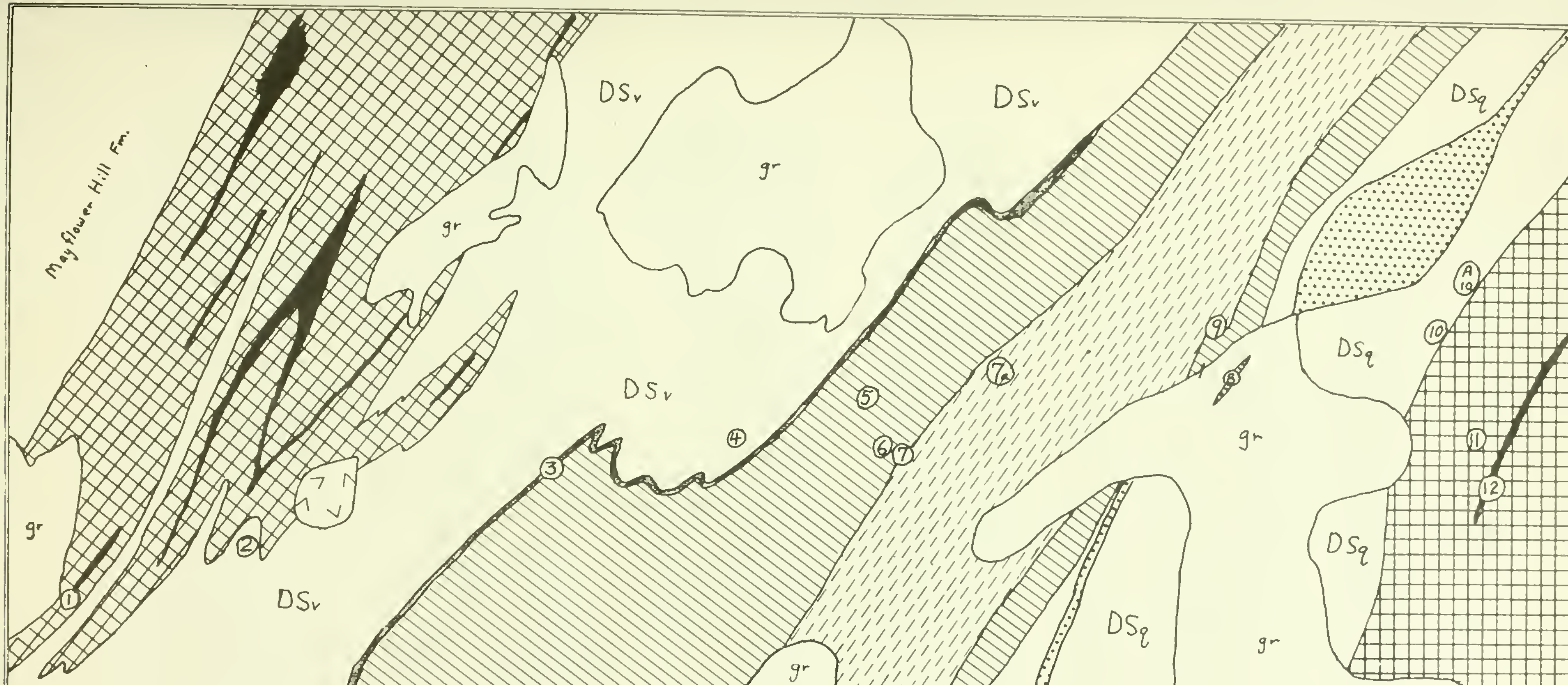


FIGURE 1

GEOLOGIC MAP OF SOUTH-CENTRAL MAINE

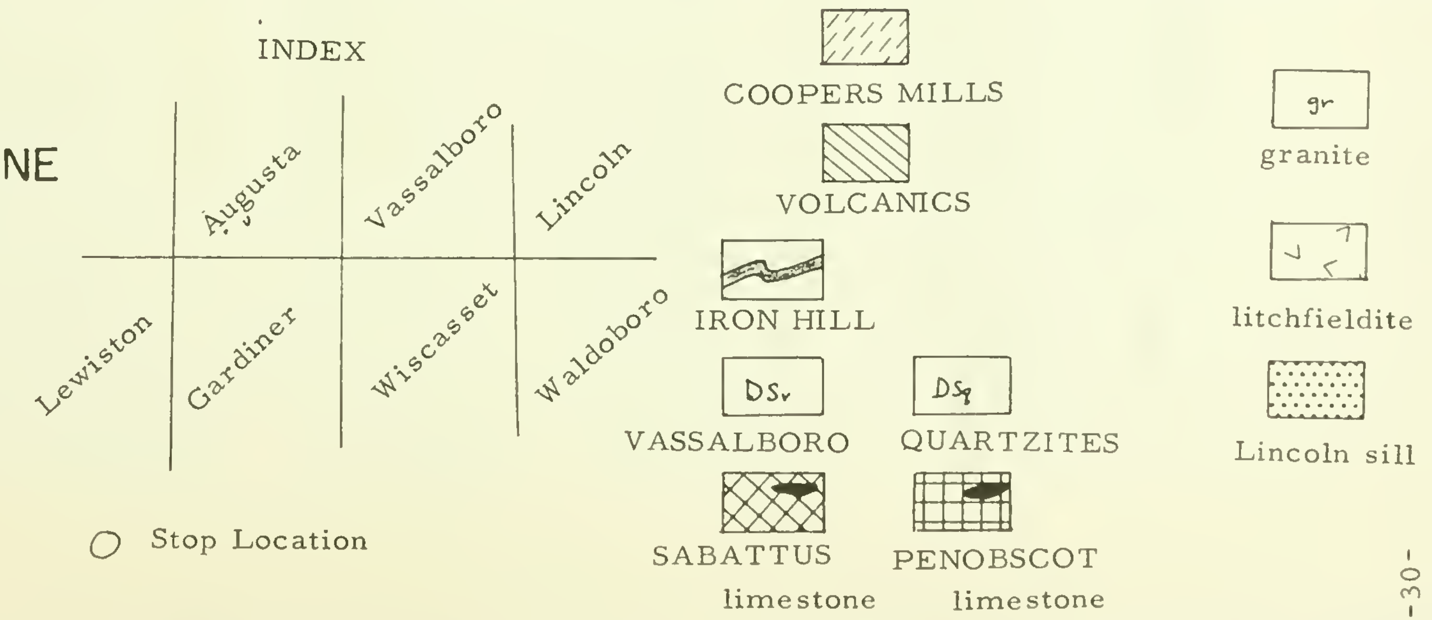
by

R. G. DOYLE

J. WARNER

A. M. HUSSEY II

1965



7.2 Enter Androscoggin County.

7.7 Through Lisbon Falls on Me. 196 and Me. 9. Enter Lewiston Quadrangle.

8.5 Right turn onto Me. 9. 0.1 miles farther bear right toward Sabattus.

14.1 Crops for the next mile are Sabattus Fm. and pegmatite.

15.6 Cross Maine Turnpike on Me. 9.

16.3 Turn right onto paved road at gray house.

17.1 Turn right back onto Me. 9 and Me. 126.

18.4 Sabattus Mountain, type locality for the Sabattus Formation to left. Stop 1 is 5 miles along strike northeast of the mountain.

19.1 Crops of Sabattus pelite with some quartzite beds.

20.5 Crop of biotite quartzite with beds of calc-silicate (Vassalboro type).

21.1 Straight through cross-road.

21.3 Turn left onto paved road. Bear right up hill.

22.2 Stop 1 Sabattus Formation

Please - Respect the farmer's pasture and fences. On the east side of road are the schists of the Sabattus Formation. This crop is particularly rich in non-maggot schist. On the west side of the road is an actinolitic marble with interbeds of actinolitic quartzite. The marble shows an elaborate fold pattern which appear to plunge under the schist. The crop to the southwest has marble at the bottom and a biotite granulite at the top. The last crop to the west is a gabbro dike.

22.5 Continue up hill and turn around at Elmvale Farm. Return to Me. 9 and Me. 126.

23.5 Turn left on to Me. 9 and Me. 126.

25.2 Enter Gardiner Quadrangle.

25.6 Enter Kennebec County.

26.3 Crop of marble and interbedded biotite quartzite on east and a rusty crop on west of road. In the woods to the east are pelites.

26.7 Crop of Vassalboro type under power line.

26.9 Crop of Sabattus type under power line.

27.1 Rusty quartzite (a common rock type at the base of the Vassalboro), then quartzite with calc-silicate beds and pods. We have just crossed a tight fold. In less than 1/2 mile across strike we saw a belt of pelite with a marble zone sandwiched between two belts of quartzite.

28.2 Stop 2 Vassalboro Formation

A typical outcrop of this unit.

28.6 Continue on Me. 9 and Me. 126. Crops of Vassalboro types.

30.2 to 31.9 Crossing litchfieldite body. Outcrops are rare; the body is mapped by its boulders and the topography. Several boulders of litchfieldite have been placed at stop 3.

32.1 Crops from here to stop 3 are various quartzites and granulites in the Vassalboro Formation.

34.6 Cross Maine Turnpike on Me. 9 and Me. 126.

35.8 Crop of biotite-feldspar-quartz granulite (a possible volcanic) in the Vassalboro Formation.

37.1 Cross bridge over Cobbosseeconte Stream. Make a sharp right turn, then a left turn up West Street.

37.8 Straight at yield sign, then a left turn onto U. S. 201 at stop sign.

38.1 Stop 3 Iron Hill Formation

North end of crop is cut by a pegmatite. Note the boulders of litchfieldite.

39.2 Continue north on U. S. 201 into Gardiner. At end of park, take the right fork down hill to stop light, then straight across intersection, then...

39.5 Cross Kennebec River.

39.7 At stop light turn right onto Me. 27 and Me. 126.

40.4 Turn left onto Me. 126.

40.6 Crop of Iron Hill Formation.

40.8 Enter Wiscasset Quadrangle. Crops of salt and pepper Vassalboro types and pegmatite.

44.3 Stop 4 Vassalboro Formation

This is a typical salt and pepper type in the "upper" Vassalboro. Typical of this part of the structure, the dips are low to the northwest - evidence that the syncline is overturned and isoclinally folded.

44.6 Continue on Me. 126. Crop of salt and pepper type.

45.3 Enter Lincoln County.

48.1 Turn left onto paved road toward Togus at Saint Denis Church (second oldest Catholic Church in Maine).

48.6 Turn right onto dirt road just short of red barn with peeling paint.

49.1 Stop 5 Volcanics

Walk through woods to west to top of ridge and 100 feet down other side. Find three crops typical of the volcanic unit. Note garnet-rich rock in rusty crop and the pale fiberous amphibole.

50.3 Continue up dirt road. Crops of biotite-feldspar granulite with beds and stringers of amphibolite.

50.6 Turn right at cross-road.

50.9 LUNCH in field to south of fieldstone house.
Ladies down hill to south, gents to the west.

52.4 Turn left onto Me. 126.

52.7 Stop 6 Volcanics

Crop in front yard of school. Intermediate volcanic phase of unit intruded by pegmatite.

53.1 Stop 7 Coopers Mills Formation and Volcanics

Park on East side of bridge over Sheepscot River. Crops on west side of bridge are volcanics with a pale amphibole. Crops under bridge and on the east bank are typical Coopers Mills Formation.

53.7 Turn left onto Me. 218.

53.9 Crops of Coopers Mills pelite.

56.1 Enter Vassalboro Quadrangle.

56.7 Stop 7a Coopers Mills Formation

Turn right onto Me. 17 and Me. 32. This stop may be eliminated if time is short. Crop to west of intersection. Type locality of the Coopers Mills Formation.

56.9 Picnic area, alternate lunch.

57.0 Bear left on Me. 17.

57.7 Crops from here to mile 62.1 are of the Coopers Mills Formation. Several of the crops near mile 59.9 have the typical lithology of the Knox Gneiss.

59.3 Enter Liberty Quadrangle.

62.0 Enter Knox County. Crop of a diabase dike cutting a Coopers Mills type micaceous quartzite.

62.1 Straight on Me. 17 through junction with Me. 206.

62.2 Crop of granite and pegmatite.

63.1 Stop 8 Lincoln Sill

Park on right in pullout near yellow "Dow" 50 gallon drums. Crop is 115 yards west on north side of road. WATCH TRAFFIC. Lincoln Sill with oriented phenocrysts intruded by granite and pegmatite. A small inclusion of the quartzite that the Lincoln Sill intruded is present. This crop is an inclusion in the granite.

63.1 Turn around and return to junction of Me. 17 and Me. 206.

64.2 Turn right onto Me. 206.

64.6 Another crop, in field to left, of the diabase dike from mile 62.0. Crops from here to mile 65.8 are in the Coopers Mills Formation.

65.8 Turn right onto Me. 105. Hills to east held up by staurolite schists in the top of the Penobscot Formation.

66.1 Stop 9 Volcanics and Coopers Mills Formation

Park at fourth maple tree, walk 100 yards to south on tote-road. Crop is on the southeast limb of a small overturned anticline. Coopers Mills to northeast, volcanics to southwest.

67.7 Continue on Me. 105. Crop of quartzite within the volcanics.

67.8 Straight through Razorville on Me. 105.

68.4 Crop of granite.

68.9 Crop of quartzites.

69.2 Straight on Me. 105 and Me. 220 into Washington.

69.3 Bear right on paved road to right of monument.

69.5 Bear left at fork in road.

70.0 Crop of granite.

71.5 Straight through cross-road.

72.6 Turn left onto dirt road.

72.8 Stop 10 Quartzites

Typical crop of quartzites.

73.3 Junction of dirt road with Me. 105.

73.3 Alternate Stop 10 Quartzites

This is the best crop of the quartzites in the region. Only go to this stop if time permits. Go straight across Me. 105 on dirt road for 1 mile, park at last house, walk up to top of hill to west behind house.

73.3 Road log continues without Alternate. Turn right (left if you went to Alternate) onto Me. 105 heading east.

75.7 Turn right onto Me. 131. Crops from here to mile 79.0 are in the belt of andalusite schist.

77.9 Stop 11 Penobscot Formation

Park at dirt road, walk up road 125 yards. The uppermost part of this unit is a staurolite schist which crops out on top of the ridge about one mile to the west. The next lower part of the Penobscot Formation is a chiastolite schist, this crop. The Penobscot has not as yet been studied farther down section. Note that the andalusite crystals are alligned with a low southernly plunge. Also, many of the andalusites are altered to sillimanite in radial growths. Several beds have as much as 35% andalusite.

77.9 Continue down Me. 131.

79.0 Bayonet turn to the left toward Union. Make a left for 200 feet on Me. 17 and Me. 131, . . .

79.1 Then a right at sign for Union (Just past Gulf station).

79.3 Stop 12 Union Quarry

Turn right into Lime Products Corporation Union Quarry. Follow quarry road. This is one of the zones of limestone in the Penobscot Formation. The rock is a pure, actinolite, or diopside-garnet marble. Most of the marble is ground and used for agriculture.

79.8 Leave quarry, turn right at quarry entrance.

80.1 Crops of rusty-weathering schist and quartzite in the Penobscot Formation.

80.2 Turn right onto Me. 235. Follow 235 for 9.3 miles to U. S. 1. Follow U. S. 1 for 40 miles to Brunswick and Bowdoin College.

TRIP C

NUBBLE, WAISANEN-TAMINEN, HARVARD MINES

Leaders: Frank Perham, West Paris, Maine, and
Roy L. Farnsworth, Bates College.

INTRODUCTION

Oxford County, Maine pegmatites appear in a great number of articles on the origins of pegmatites as well as an accounting of the rare mineralizations which occur in them. Pegmatite is a very common rock in this section of Maine and the countryside is scarred with quarries either being worked regularly, spasmodically, or a past operation. These quarries have been operated for recovery of feldspar, mica or beryl; many of these being hand cobbed operations.

The purpose of the present field trip is to show some typical examples of the pegmatites of this region with an opportunity for some mineral collecting. The trip has been arranged to show within a relatively small area a simple pegmatite, to a more complicated one, and end with a considerably more complex one.

The quarries are owned and operated by Stanley Perham. His son Frank has done the most recent work in these quarries and in so doing has carefully noted mineral relationships there. It is from his first hand experience and observations that we can gain a further insight into these pegmatites.

Directions to Reach the Area

Take Route 201 through Topsham to junction with Route 196. Go left on 196 to Lewiston (city center). Go left on Route 11 (with others) and proceed to junction with Route 26 at Welchville. Follow Route 26 through Norway and South Paris to junction with Route 219 at Trapp Corner, West Paris (Maine Mineral Store on the left). Turn left onto Route 219 and proceed 8 miles as per the sketch map (Figure 1) to the road to the quarries.

Brief Historical Sketches of the Mines

Nubble:

First operated for feldspar by Matti Waisanen about 1935. During

World War II it was worked for mica, producing some of the highest grade mica produced in New England; some pieces were up to 3 feet in diameter.

Waisanen Mine:

Also operated for feldspar about 1935 by the Oxford Mining and Milling Co. During 1943-1944 it was mined for mica by the Douglass Mining Co.

Harvard Mine:

Quarry opened for quartz crystals in 1800's by Isaac Noyes of Norway
1917 Mineral rights obtained by Harvard Museum
1923-24 quarried for Harvard Mineralogical Department
Also quarried in 1943 for mica

Mine explanations

Nubble Mine

A simple Pegmatite. Geologic emplacement (interbanded biotite schist and calci-silicates). Muscovite rich -- quartz core -- traprock dikes. Late state emplacement fingering out of the pegmatite vertically showing crystallization of minerals at apex.

Waisanen and Tamminen Mines

Waisanen: contacts -- relation of mineralization of pegmatite to explanation of mineralization around feldspar crystals and vug formation--- Herderite and Bertrandite crystals.

Tamminen: Example of secondary lithia stage. Quartz crystallization (tabular-pseudo cubic parallel growth, etc.)
Lepidolite mass with rare phosphates.
Pollucite crystals, first identified in the United States.

Harvard Mine

Famous multi-stage crystallized pegmatite
- Tourmaline stage
- Apatite stage
- Quartz pseudomorph stage
- Emplacement in schist with evident secondary soda spar zones with tourmaline and quartz crystal vugs. Recrystallization of primary muscovite zone into green tourmaline

Finish time collecting on the mine dump and enjoying the view

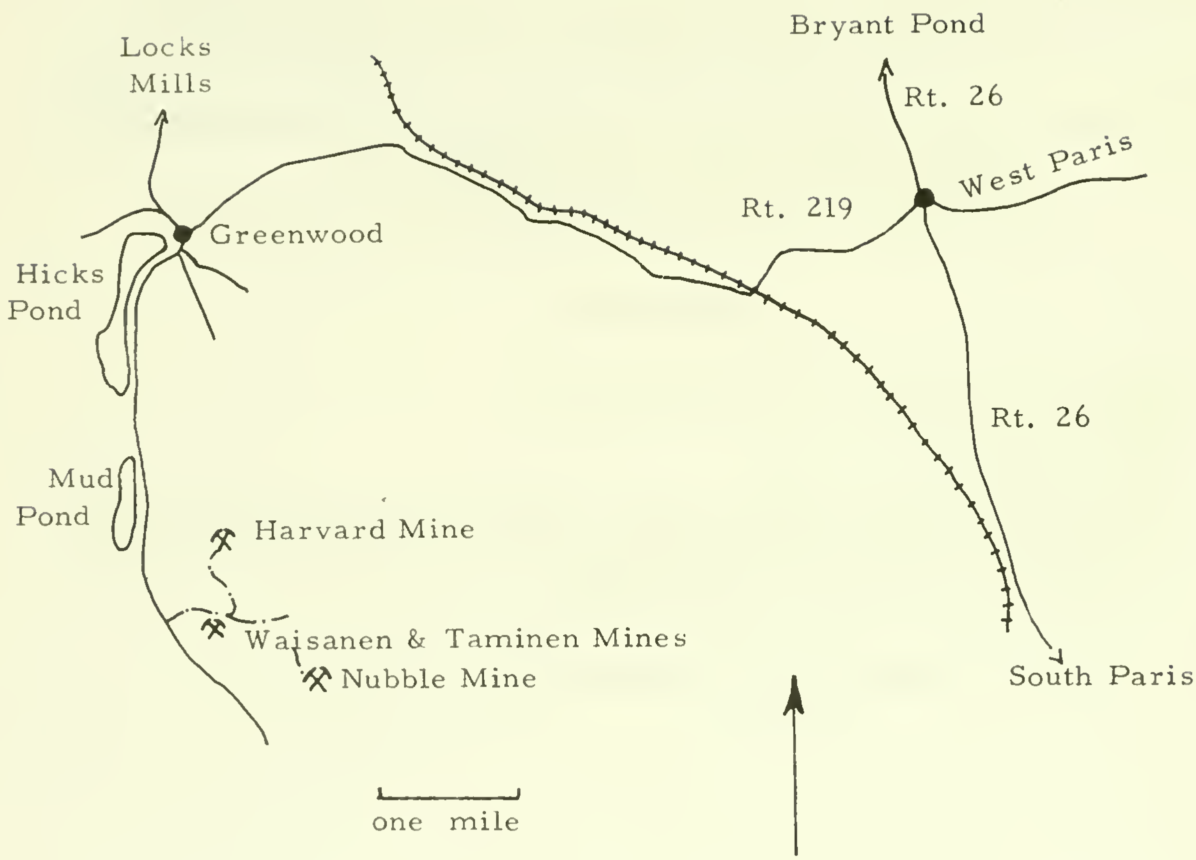


Figure 1. Location of pegmatite mines, Greenwood area, Maine

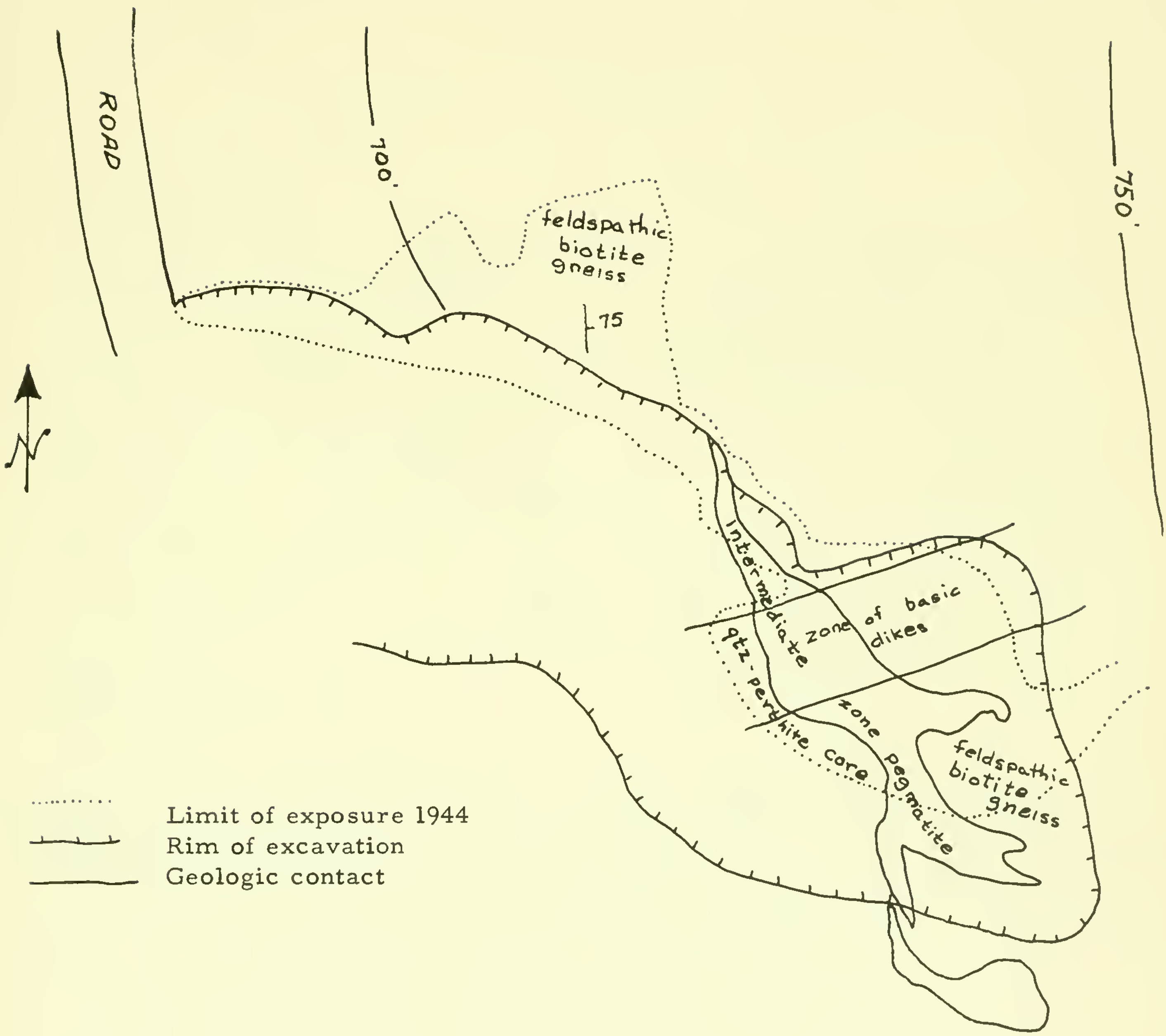


Figure 2. Sketch map of the Waisanen Mine, Greenwood, Maine. (Adapted from the U. S. Geological Survey Professional Paper 255)

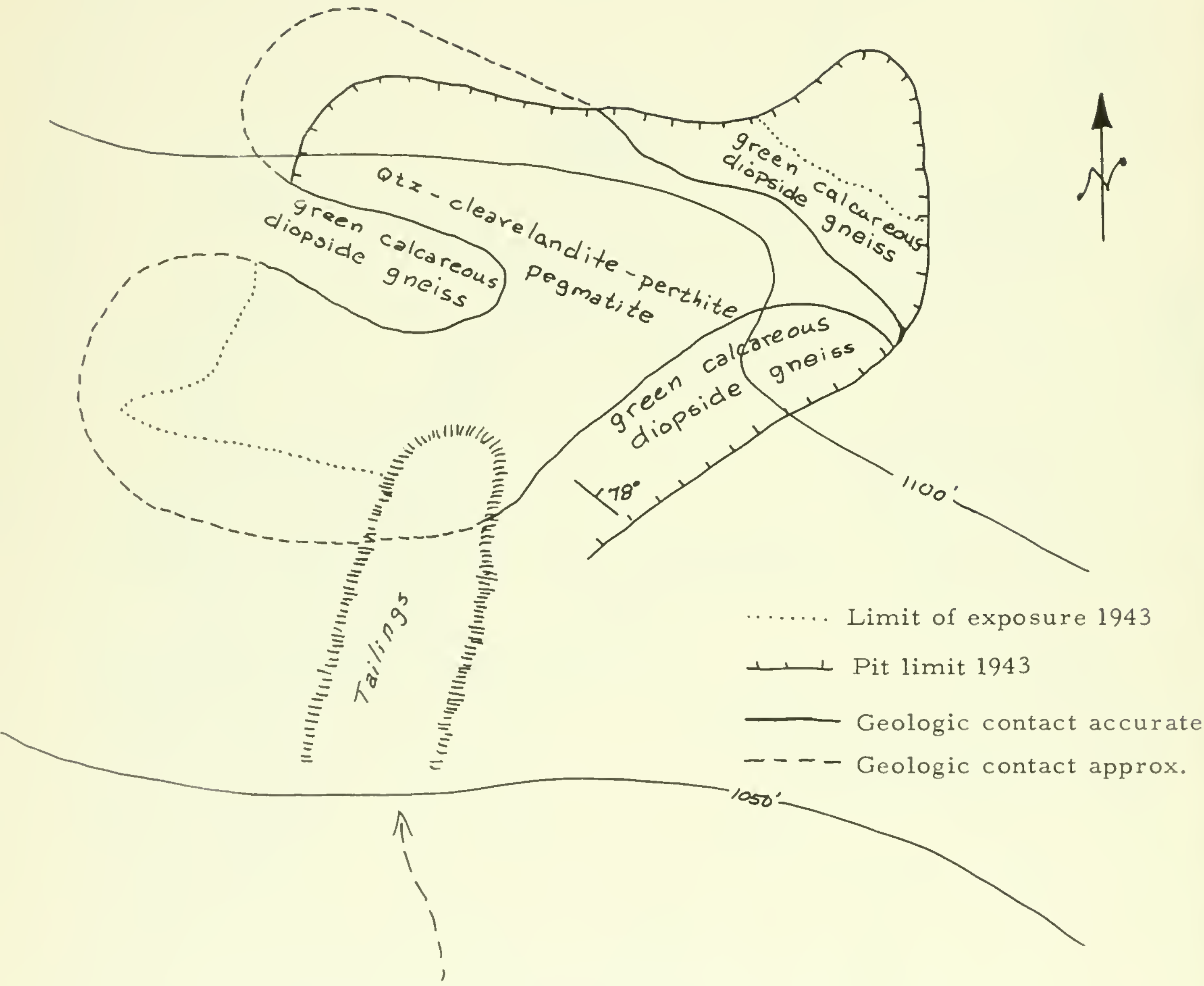


Figure 3. Sketch map of the Harvard Mine, Greenwood, Maine. (Adapted from U. S. Geological Survey Professional Paper 255.)

TRIP D

LATE-GLACIAL STRATIGRAPHY OF THE KENNEBEC RIVER VALLEY FROM NORRIDGEWOCK TO SOLON, MAINE

H. W. Borns, Jr., Dept. of Geological Sciences, Univ. of Maine

D. J. Hagar, Dept. of Geology, Univ. of Mass.

INTRODUCTION

As the last ice sheet that covered this area (Cary?) dissipated, the early post-glacial sea transgressed to form an estuary of the Kennebec River valley at least as far north as Bingham, Maine. At times the glacial ice stood in or close to the sea. The transgressing sea reached its highest position approximately 12,930 Yrs. B. P. The Presumpscot Fm. (marine silt-clay) was deposited primarily during the marine transgression while the dissipating ice sheet was still able to contribute large volumes of melt-water and rock flour to the sea. As the region emerged, sandy outwash of the Embden Fm., derived from the dissipating ice sheet, aggraded over the surface of the Presumpscot Fm. As emergence continued, with the source of outwash possibly removed, the early Kennebec River incised the Embden and Presumpscot Fms. The regimen of the river changed and the coarse gravel of the North Anson Fm., possibly outwash from a late Pleistocene ice cap, aggraded unconformably on the Presumpscot Fm. At present the Kennebec River is degrading the North Anson Fm. (See the geologic cross-section presented in Fig. 1)

The geologic sequence of events, radiocarbon dates in the area and correlation of events of the Maine, Quebec, New Brunswick and Nova Scotia region suggest that the last extensive ice sheet to cover the region dissipated more rapidly in eastern Maine and New Brunswick than in the highlands of New Hampshire and western Maine. The data also suggest that ice persisted in the highlands during the Cary-Port Huron Interstade, perhaps dissipating during the Port Huron-Valders Interstade. These highlands probably later became a center for ice accumulation and radial outflow. This ice cap probably grew synchronously with the main Valders ice sheet to the north, with cirque glaciers on Mt. Katahdin, Maine, and with the ice cap in south-western Nova Scotia.

Literature dealing with the surficial geology of this region includes Stone (1899), Leavitt and Perkins (1935), Trefethen (1944), Goldthwait (1949), Caldwell (1959), Borns (1963), and Borns and Hagar (in press).

QUADRANGLE MAPS NEEDED

Waterville, Norridgewock, Anson and Skowhegan. Stops are in the Anson quadrangle.

ASSEMBLY POINT

In Waterville at the Elmwood Hotel.

TIME

Trip will leave by bus at 8 a.m. sharp.

ROAD LOG

Mileage	
0.0	Elmwood Hotel. Proceed north on Route 104.
4.3	Fairfield Center
6.4	At Holway Corner go left on Route 139.
10.3	Beginning of "The Plains." Gray-blue marine silt and clay (Presumpscot Fm.) overlain by fluvial sand (Embden Fm.).
13.6	Buffalos in pasture on right.
14.4	Sand dunes, derived from the Embden Fm. by westerly winds, on slope of hill to the right.
14.5	Intersection of Routes 139 and 2. Follow Route 2 to the right through Norridgewock.
15.0	Intersection of Routes 201A and 2. Follow 201A to right across the Kennebec River. This route post-dates the map. It crosses kame terraces, till and bedrock in this section at an altitude of approximately 260-280 feet. A large esker parallels the river on the opposite side.
21.0	Stop #1. "Esker-delta" at Old Point, Madison. This esker can be traced, as a series of segments, from Norridgewock, up the Kennebec River valley to Bingham, a distance of at least 25 miles. It is doubtful that these

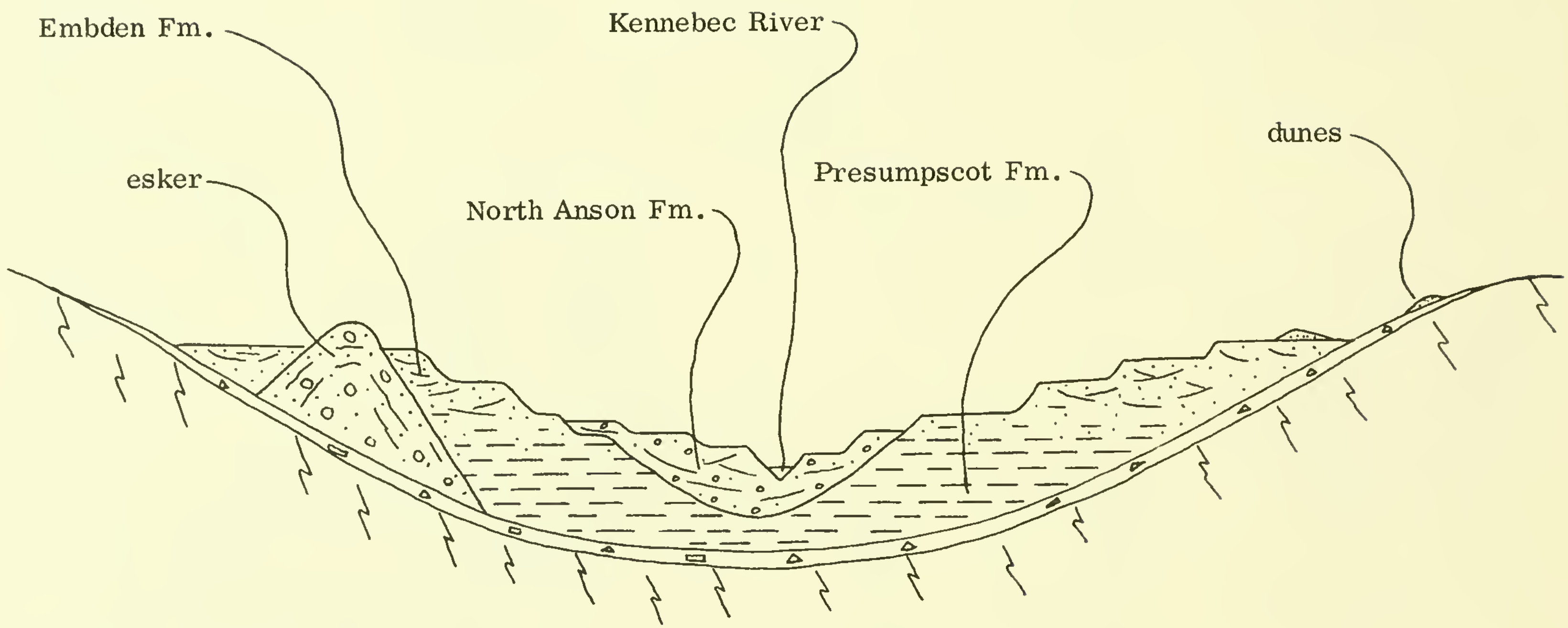


Fig. 1 Generalized geological cross-section of the northern Kennebec River valley, Maine.

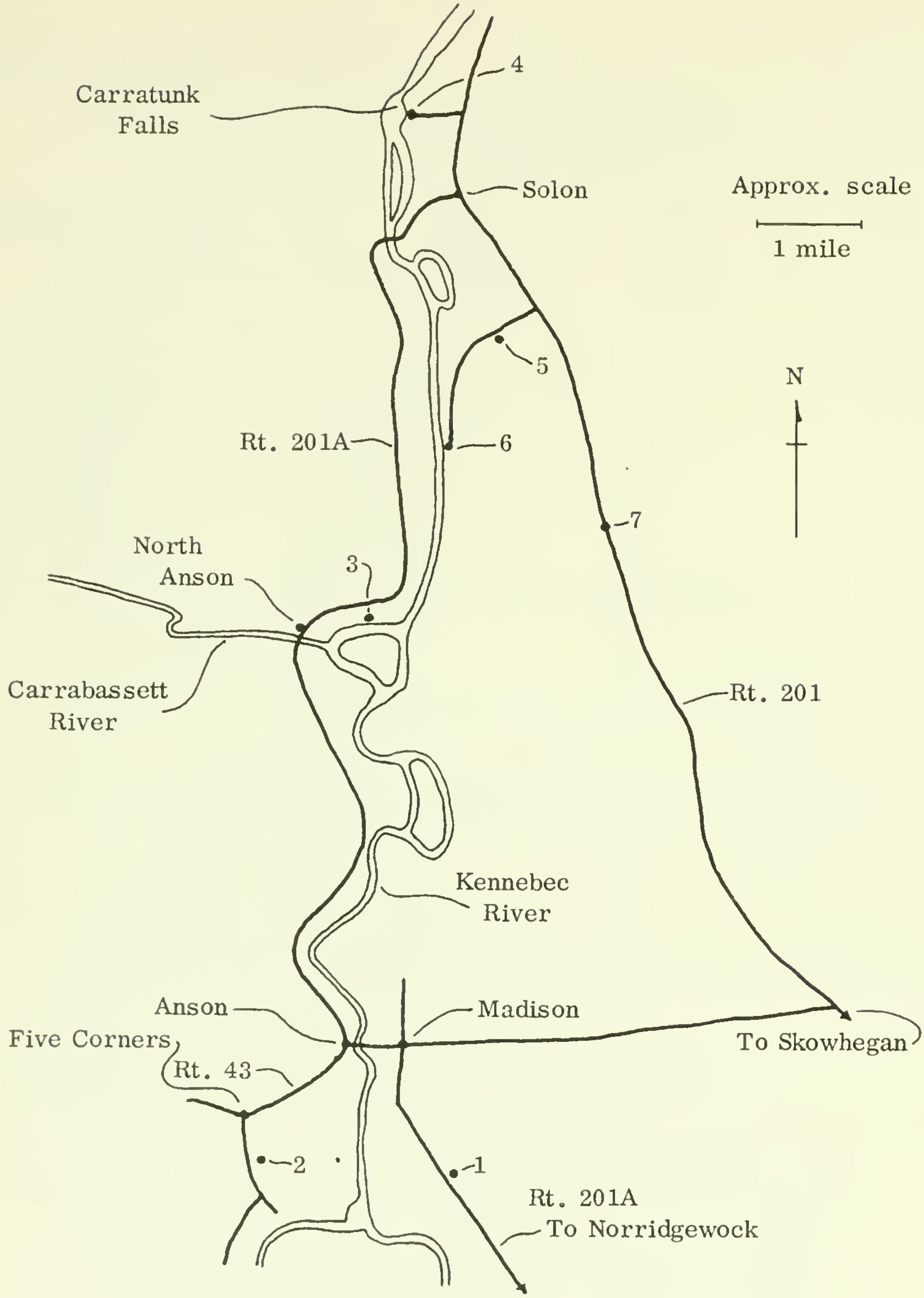


Fig. 2 Index map

segments were the product of a single, continuous glacial river. The gravel mound on the east side of the road has a thickness of at least 180 feet. The mound on the west side of the road is a marine delta composed of sand, cobble and pebble gravel interfingered with the fossiliferous (_Macoma calcarea_ Gmelin) silt-clay of the Presumpscot Fm. Good exposures would show deformation within the delta suggesting that glacial ice was present during its construction.

23.0 Intersection of Routes 201A and 148 at Madison. Follow Route 148 to left across the Kennebec River to Anson. The falls at Madison acted as a temporary base level which controlled the pre-North Anson Fm. depth of incision into the Embden and Presumpscot Fms. upstream. Continue to Five Corners. Route is on depositional surface of the Embden Fm.

24.7 Presumpscot Fm., underlying the Embden Fm., exposed on right in valley.

24.9 Intersection of Routes 148 and 43 at Five Corners. Take Route 43 to left.

25.4 _Stop #2_ . In the exposure under the powerline, the marine Presumpscot Fm. grades upwards into the fluvial Embden Fm. This transition represents a withdrawal of the sea from its upper limit accompanied by an influx of sandy outwash into the shoaling estuary. The Embden Fm. has been traced upstream into ice-contact heads. The barn on the opposite side of the road rests on till. Back track to Anson.

27.2 Intersection of Routes 148 and 201A in Anson. Follow Route 201A north. Benedict Arnold portaged these falls in October 1775 on his way to Quebec.

30.9 Note pirated channel of the Carrabassett River on left.

32.0 North Anson. Continue up-river on Route 201A. The route travels on the depositional surface of the Embden Fm. at an altitude of approximately 340 feet.

32.9 _Stop #3_ . Follow the power line to the right. This offers a marvelous panorama of the Kennebec River

and its valley. The Embden Fm. at the top of the escarpment grades downward into the Presumpscot Fm. at the base. The upper marine limit in this area is at an altitude of approximately 400 feet and fossil shells (Portlandia glacialis Gray) collected on the shore of Embden Pond were dated at 12, 930 200 years B. P. (Y-1477). Proceed up-river on Route 201A.

34.8 Note river-cut terrace on right. Proceed up-river upon the Embden Fm. through the town of Embden.

39.3 Follow Route 201A across the Kennebec River and into Solon.

40.4 Intersection of Routes 201A and 201. Follow Route 201 to the right.

41.1 Turn left at Tewkbury's house to Carratunk Falls.

41.6 Stop #4 . Lunch. Carratunk Falls. The falls acted as a base level which controlled the pre-North Anson Fm. depth of incision of the Embden and Presumpscot Fms. upstream. Return to Solon and continue downstream along Route 201 on the depositional surface of the Embden Fm.

44.2 Follow road to right past cemetery to gravel pit on right.

44.6 Stop #5 . Pit in the upper part of the Embden Fm. exposing good fluvial cut-and-fill structure. Leave pit, turn left toward the Kennebec River.

45.8 Stop #6 . Coarse gravel of the North Anson Fm. resting unconformably upon the Presumpscot Fm. This is best seen in the riverbank exposure. Backtrack to Route 201.

47.6 Turn right on Route 201.

47.7 Embden Fm. exposed at top of hill and the Presumpscot Fm. in stream at the base of the slope.

50.3 Stop #7 . Aeolian sand, derived by westerly winds from the Embden Fm., deposited upon till. Ventifacts are common in cuts on both sides of the road. Don't take them all! Note dune topography in the field to the left (east) of the road. Proceed south on Route 201.

60.2 Beginning of the Skowhegan "plains." The stratigraphy here is the same as "The Plains" in Norridgewock. Follow Route 201 into Skowhegan, across the Kennebec River to the Elmwood Hotel in Waterville.

82.6 Elmwood Hotel, Waterville.

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TRIPS E AND J

Blue Hill Copper Mine

Leaders: Lester Greenwood and John Hogan, Geologists.
Black Hawk Mining Co.

HISTORY

The most productive mine in the area was the Douglas, which was operated from 1878 - 83 and again during the first world war from 1917 - 18. This property is localized along a copper-rich, zinc poor zone of mineralization and is reported to have produced from two to three million pounds of copper.

Numerous other shafts and pits dot the area and attest to the activity that was part of the famous Maine mining boom.

REGIONAL GEOLOGY

The regional setting is the Ellsworth Formation, of Silurian (?) age. This formation is generally considered to be in the greenschist facies or somewhat higher.

There are numerous large intrusives - mostly granites - which intrude the Ellsworth along the coast. The section with which we are interested here is thought to be about middle Ellsworth.

LOCAL GEOLOGY

Allen Quartzite Member

Dense grey to mauve quartzite, includes some banded to weakly banded sections, conglomeratic and biotitic in part.

Transition Zone:

A zone of interbedded quartzite, biotitic quartzite, and quartzitic gneiss and biotite gneiss layers. Grey to dark brown with purple zones. This area is also characterized by numerous granite tongues, pods, lenses, and by granitization of the local rock.

Biotite Gneiss Member

Dark brown to tan, spotted - mottled, with grey and blue-black porphyroblasts. Rich in biotite, quartz and secondary minerals porphyroblastic in texture.

Shows some local bedding and in part is more schistose than gneissic. In places this unit has a conglomerate with a few brown pebbles at the base. Thickness - 300 feet.

Transition Zone

A zone of interbedded pea conglomerates, altered volcanics-amphibotites, with zones of over 50% free quartz with dark grey quartzitic fragments. Thickness 20-40 feet.

Pond Quartzite Member

A dense grey to blue grey quartzite with well-developed bedding generally very regular but occasionally crenulated. A conglomerate with 1/4 to 1 inch grey and brown pebbles is found at the base. Thickness - 200 feet.

Banded Quartzite Member

Composed almost entirely of delicate finely banded, often crenulated, quartzite with green-chlorite, brown biotite, orange calcium silicates, white feldspar, and grey quartz. A conglomerate at base of this formation contains 1/4" pebbles and is usually distinct. Thickness - 175 feet.

Douglas Quartzite Member

A dense grey quartzite with granular texture, contains some broad open folds. A pea conglomerate is found at the base. Thickness 250 feet.

IGNEOUS ROCKS

Granites

Coarse-grained grey porphyritic biotitic granite with prominant potash feldspar phenocrysts.

Feldspar Porphyry

Tabular feldspar phenocrysts 1/8 inch in a fine grained grey to black groundmass.

Diorite

Coarse to fine grained dark green, dense, with clots of hornblende crystals.

Volcanics

The Pond Quartzite and the transition zone between the biotite gneiss and the Pond Quartzite contain lenses of what is thought to have been somewhat basic flows or tuffs. This rock as seen now is an amphibolite.

METAMORPHISM

The investigations underground here at the mine site are just starting. Very little microscopic work has been done up to this time. It is expected that more detailed information on the mineralogy will be obtained shortly. The Ellsworth Formation is generally considered to be greenschist facies or slightly higher. At the mine site contact metamorphic effects are superimposed upon these of the regional metamorphism. Tentatively the area in which the mine workings are operating is placed in the amphibolite facies.

HYDROTHERMAL ALTERATION

Alteration of granites near ore zones is characterized by the presence of dark green feldspar alteration. There is also a type of alteration which causes dark green to light green patches and clots in the feldspars, and is attributed to epidote and or chlorite. Other evidences of hydrothermal solutions are shown by bleaching of some joints and fractures and by filling of other joints and fractures with pyrite, fluorite, rhodochrosite and ore minerals. Chloritic alteration is noted in all units especially in the altered volcanics.

ORE ZONES

Copper, lead and zinc are the metals to be recovered from this mine. It is expected that the chalocpyrite will be found in the Pond Quartzite Member near the Banded Quartzite horizon. The chalcopyrite occurs as an intergranular replacement in the quartzite and is controlled by the bedding. It is not clear why the chalcopyrite exhibits a preference for certain bedding horizons and not others.

Zinc mineralization occurs as sphalerite and is found at the footwall of the Biotite Gneiss Member and in the transition zone between the biotite gneiss and Pond Quartzites. Sphalerite occurs as a massive replacement of granite and quartzite, and as a partial replacement of amphibolites.

Lead mineralization occurs as galena and is found as massive to partial replacement of amphibolites and granites in the transition zone between the Biotite Gneiss and Pond Quartzite Members.

SURFACE FACILITIES

The Black Hawk facility consists of two major buildings and several core shacks and pump houses. The service building encloses the collar of the shaft and contains the Black Hawk offices, Accounting Dept., Assaying Dept., Geology Dept., and Engineering Dept., the contractors office and the dry room. The headframe, an A frame type, which is adjacent to the service building, is 112 feet high to the center of the sheave block and is built around two ore bins, one of 700 tons capacity and one of 80 ton capacity. The second major building incloses the hoisting equipment and compressor. The hoist is a 3 1/2' x 6 1/2' double drum Nordberg hoist powered by a 300 HP motor. The compressor is a Joy 3300 cfm and is powered by a 600 HP electric motor. Electrical power comes in to the property 33,000 volts on Bangor Hydro Line and is transformed to 2300 volts, 550 volts and 110 volts in a transformer station which is next to the hoist house.

FIELD TOURS

Tour of surface facilities
Surface tour of old Douglas Mine
Surface tour of old Mammouth Mine
Inspection of typical rock types from underground.

TRIP F

Stratigraphy and Metamorphism in Southwestern Casco Bay

Leader: Marc W. Bodine, Jr.
State University of New York at Binghamton

Objectives of Trip

This excursion will visit the area in Cape Elizabeth where the several formations of the Casco Bay Group as originally defined by Katz (1917) and the older Cushing Formation are exposed with metamorphic grade ranging from the chlorite subfacies through the almandine subfacies of the greenschist facies using the Eskola facies classification as modified by Fyfe, Turner, and Verhoogen (1958). Additional stops will be made in Falmouth where the lowest unit of the Casco Bay Group is exposed exhibiting lower almandine amphibolite facies metamorphism in contact with the Pejepscot Formation (Fisher, 1941), a highly migmatized quartz-biotite-plagioclase schistose paragneiss of the sillimanite subfacies of the almandine-amphibotite facies. The evidence for interpreting this contact as a fault contact is the abrupt change in metamorphic grade and the abrupt appearance of pegmatites, granites, and migmatites.

Figure 1 is a sketch geologic map of the western portion of the Casco Bay quadrangle showing the route of the trip.

Outlines of Geology

The Casco Bay Group comprises a sequence of about 2000 feet of chiefly metasedimentary and minor metavolcanic rocks forming a series of anticlinal and synclinal structures trending approximately northeast. In the core of the major anticlinal structure, an older metavolcanic unit, the Cushing Formation is exposed from several miles southwest of Fort Williams on the east coast of Cape Elizabeth northeast through Casco Bay making up the major islands of the bay (Cushing, Peaks, Long, and a portion of the Chebeague Islands to Birch Island and Mere Point in the northern part of the bay). The northwestern shore the bay from Falmouth through Freeport forms the approximate fault line contact between the Casco Bay Group and the more intensely metamorphosed Pejepscot Formation. Within Casco Bay the isograds are approximately east-west with the chlorite zone occurring in southernmost Cape Elizabeth, the biotite and garnet isograds passing through Broad Cove and Zeb Cove respectively on Cape Elizabeth. The staurolite and sillimanite isograds are not observed within the Casco Bay quadrangle

except for the northeastern corner where staurolite is observed on Harpswell Neck with the sillimanite isograd lying farther to the north.

Sequence of Rocks

1. Pejepscot Formation. Defined originally by Fisher (1941) from a sequence of rocks in the village of Pejepscot about three miles northwest of Topsham in Androscoggin County (Freeport 15' sheet), this unit can be extended south through the Freeport and northwestern Casco Bay quadrangles. The unit is essentially a quartz-biotite-plagioclase schistose paragneiss containing numerous thin beds of calc-silicate (diopside-hornblende) gneiss and diopside marbles. Sillimanite, in places kyanite, and almandine are the major indicative silicate accessory minerals with sphene, tourmaline, magnetite, apatite also present. In places the rock is highly migmatized with bands of quartz-microcline-plagioclase with some pegmatite banding always present. Pegmatites, both concordant bands, sills, lenses or pods, and discordant masses and dikes, are ubiquitous but variable throughout the unit in this area. Numerous small biotite granite to granodiorite stock-like to dike-like bodies occur in the unit often approaching an aplite texture. The age of the unit is unknown although it is presumably Silurian or older. Potassium argon ages from the M. I. T. laboratory on biotite from pegmatite in Cumberland gives an age of 252 m. y. (Appalachian).

Associated with the Pejepscot Formation is an amphibolite unit, the "Bartlett Point" * Amphibolite, which is exposed on Bartlett Point, Sturdivant Island, Wolf Neck, and along the coast near Bunganuc Landing. About 200 feet thick the unit is a coarse hornblende-plagioclase (bytownite at Bartlett Point)-diopside rock. This may be the unit mapped as the Androscoggin Formation by Fisher (1941) in the Lewiston area.

2. Cushing Formation. Originally named the Cushing Granodiorite by Katz (1917) from exposures on Cushing Island, this unit, which conformably underlies the Cape Elizabeth Formation, consists chiefly of a massive to poorly foliated quartz-plagioclase-microcline-biotite-muscovite blastoporphyritic gneiss. Compositionally and texturally the rock apparently is a felsitic metavolcanic. Agglomerate and tuffaceous features are noted in the northern part of the Freeport quadrangle and in the Bath quadrangle currently being mapped by Dr. Hussey at Bowdoin College. In the Casco Bay area only the upper part of the unit

*The geographical portion of the name is placed in quotes to indicate this is an informal name used here in advance of formal definition to appear elsewhere. [Editor]

is exposed forming the core of the central anticlinal structure. In the uppermost portion of the unit several darker, hornblende bearing, beds are noted. The contact with the Cape Elizabeth Formation above is gradational with a sequence of fifty feet or more of alternating beds of Cape Elizabeth and Cushing lithologies.

3. Casco Bay Group. Defined by Katz (1917) this sequence of rocks includes about 2000 feet of strata which outcrop throughout most of the Casco Bay region from Cape Elizabeth through the Harpswells. Its varied lithologic units which are traversed by the metamorphic isograds make this an ideal area for studying various mineralogical and chemical phenomena of metamorphism.

a. Cape Elizabeth Formation. A series of sandy beds grading upward into more argillaceous rocks overlying the Cushing Formation, comprise the Cape Elizabeth Formation. Most of the sandy beds are fine to medium grained, thin to thick bedded, greywacke to subgreywacke. Several are calcareous or dolomitic. The sandy beds are separated by light to dark grey phyllites or schists, occasionally carbonaceous, which give rise to the laminated appearance of the rock. In the basal portion the rock is dominantly sandy with a few conglomeratic beds present. The unit is about 600 feet thick.

b. Spring Point Greenstone. Presumably a metabasalt, this unit of variable thickness, is a typical chlorite rich phyllite in the southern Cape Elizabeth area becoming actinolite bearing in the Spring Point and Portland area.

c. Diamond Island Slate. A thin, generally less than fifty feet thick, unit of silica rich, carbonaceous, pyritic pelite, that overlies the Spring Point Greenstone, this formation, along with the Spurwink Limestone, forms a valuable marker horizon. Its characteristic even bedding and black color are very distinctive.

d. Scarboro Phyllite. A relatively thick unit of aluminous rocks consisting of richly pyritic muscovite-chlorite-biotite beds of phyllite or schist with undulatory foliation, this formation makes up one of the major units of the Casco Bay Group. Garnet-hornblende- and andalusite/kyanite-staurolite occur at various localities in the higher metamorphic grades on Harpswell and nearby islands.

e. Spurwink Limestone. This unit is a relatively calcareous sequence forming a ribbon limestone of alternating clay-rich and clay-poor beds. Thicker schistose inter-beds are common resembling the Scarboro lithology. The total thickness does not exceed 100 feet.

f. Jewell Island Phyllite. Almost identical to the Scarboro Phyllite, this unit lies above the Spurwink Limestone, and without outcrops of the limestone for reference it is impossible to distinguish from the Scarboro.

4. Basalt diabase dikes and sills. Generally thin, from several inches to rarely over 20 feet thick, these intrusives are post-metamorphic and show generally very narrow contact metamorphic effects on the enclosing wall rock. They intrude all of the above mentioned units, and are believed to be of Upper Triassic age. In general their trend is subparallel to the regional structure although some of the larger bodies (20 feet thick) are strongly discordant.

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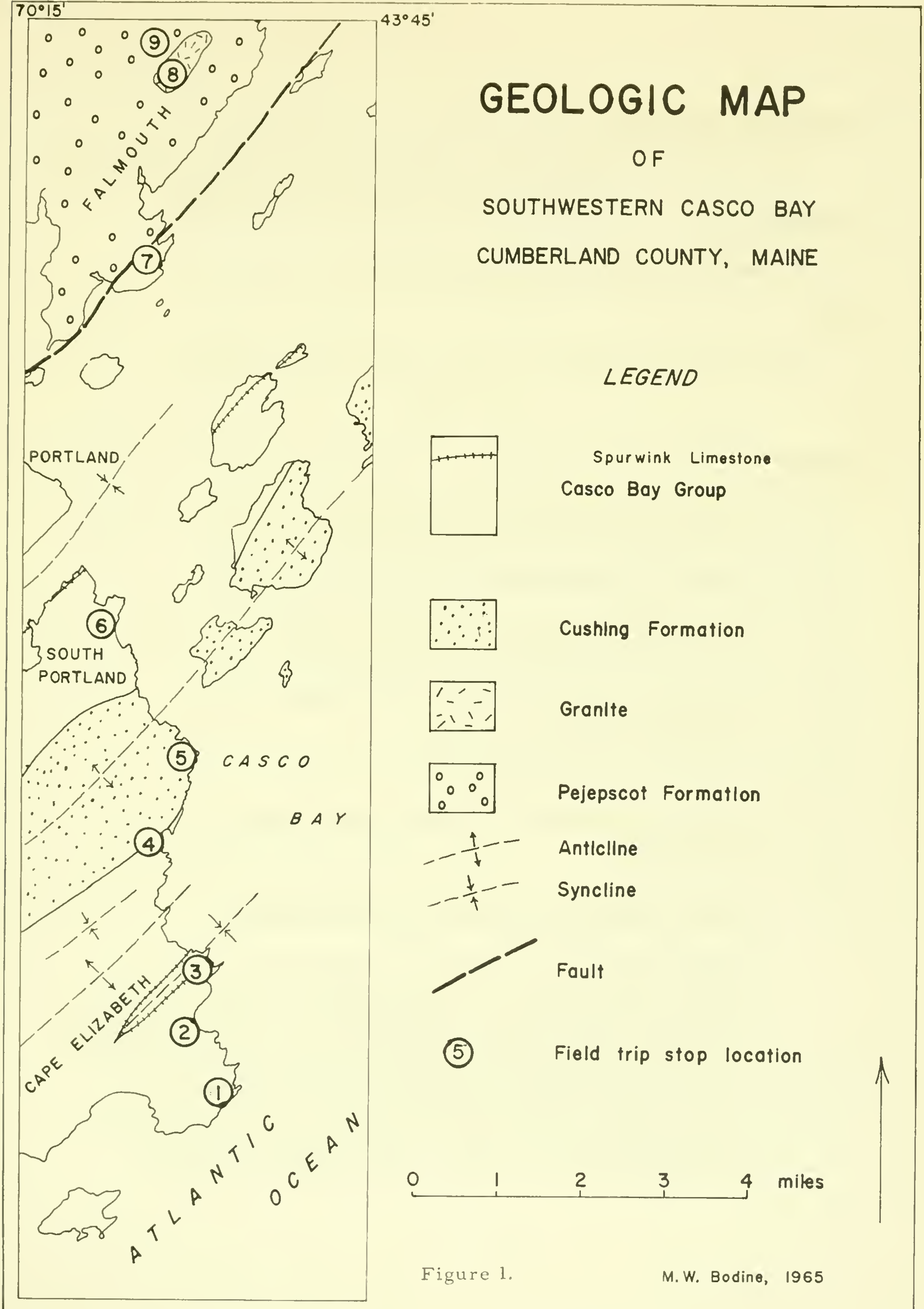
GEOLOGIC MAP
OF
SOUTHWESTERN CASCO BAY
CUMBERLAND COUNTY, MAINE
LEGEND
Spurwink Limestone
Casco Bay Group
Cushing Formation
Granite
Pejepscot Formation
Anticline
Syncline
Fault
Field trip stop location
0 1 2 3 4 miles
70°15'
43°45'
FALMOUTH
PORTLAND
SOUTH PORTLAND
CASCO
BAY
CAPE ELIZABETH
ATLANTIC OCEAN
M. W. Bodine, 1965

Figure 1.

Quadrangle Maps Needed

Cape Elizabeth, Portland East, Yarmouth, Freeport 7 1/2' quadrangles; Casco Bay and Freeport 15' quadrangles.

Assembly Point

In front of Cleaveland Hall, Bowdoin Campus.

Time

Trip will leave at 8:00 A. M. sharp, Sunday, by private car.

ROAD LOG

Mileage

0.0 In front of Cleaveland Hall on the Bowdoin Campus. Proceed to the west gate of the College.

0.1 Turn left (south) onto Bath Road (Maine Route 24).

0.2 Bear right and merge onto Maine Street (Maine Route 24) and continue through downtown Brunswick.

0.7 Turn left onto entrance ramp to U.S. Route 1 south and merge onto Route 1.

1.4 Sharp right turn continuing on U.S. Route 1.

2.9 Remain straight ahead on divided highway which now becomes Interstate 95.

3.4 From here to just north of Portland on Interstate 95 and 295 the road cut outcrops are of the Pejepscot formation.

The Pejepscot formation consists essentially of a coarse quartz-biotite-plagioclase schistose gneiss containing variable bands of microcline-quartz-albite migmatite. Pegmatities, both concordant lenses, pods, and stringers and discordant dikes and irregular masses are very common. North of Brunswick these make up the Topsham pegmatite district where a string of quarries have been operated for feldspar. Numerous pegmatite minerals (beryl, tourmaline, topaz, uraninite, etc.) have been found in these quarries. A few smaller but similar

quarries have been worked two to three miles east of here. In addition to the pegmatites, numerous small granite to granodiorite bodies occur in the Pejepscot Formation. Field relations in the Casco Bay and Freeport quadrangles indicate that the Pejepscot Formation is older than the Casco Bay Group and, at least, in the western part of the Casco Bay region, it is proposed that a major fault forms the contact between the Casco Bay Group and Pejepscot Formation.

13.9 Junction with South Freeport Road. Casco Bay Motel on left.

14.4 Bridge over Cousins River.

16.1 Bridge over the Royal River in the town of Yarmouth.

19.6 to 21.1 Extensive outcrops of the Pejepscot Formation in road cuts. Notice the later discordant pegmatites cutting the migmatized Pejepscot formation and the concordant pegmatites. At 21.1 note the thin vertical basalt dike on the left. These dikes are common in this region and are presumably of Triassic age.

21.4 Remain straight ahead on divided highway which becomes Interstate Route 295. Interstate Route 95 heads west to link up with the Maine Turnpike.

23.2 Bridge over the Presumpscot River on the northern outskirts of Portland.

25.8 Bear right onto Washington Avenue (U.S. Route 1A) ramp off Interstate Route 295.

26.1 Bridge over Back Cove. Remain on U.S. Route 1A and Maine Route 26 on Washington Avenue to downtown Portland.

27.1 Turn right onto Cumberland Avenue (Maine Route 26).

28.1 Turn left onto State Street (Maine Route 77).

28.3 Crossing Congress Street at Monument Square. Bear slightly to the left remaining on State Street (Maine Route 77).

28.7 Turn right onto bridge entrance remaining on Maine Route 77.

28.9 Sharp left turn onto bridge crossing Fore River (Portland's waterfront area) from Portland to South Portland on Maine Route 77 (Ocean Street).

29.7 Bear right remaining on Ocean Street (Maine Route 77).

29.9 Continue straight ahead on Ocean Street (Maine Route 77).

32.8 Bear left remaining on Ocean Street (Route 77). The small outcrops along the road are the Cushing Formation, a quartz-feldspar-muscovite-biotite metavolcanic gneiss immediately underlying the Casco Bay Group.

33.0 Left then immediate right turn in the community of Pond Cove remaining on Ocean House Road (Maine Route 77).

33.1 Cape Elizabeth town hall on left.

33.4 Remain straight ahead on Maine Route 77.

34.0 Outcrops of the Scarboro Phyllite and Spurwink Limestone in the core of a small syncline.

34.7 Turn left onto Two Lights Road.

34.8 Bear left remaining on Two Lights Road.

35.7 Entrance to Two Lights State Park.

35.8 Pass admission booth and continue into the park area.

36.0 STOP NO. 1 Two Lights State Park

Park in parking lot to the left of the road and walk to the shore.

The round concrete platforms are 6 inch naval gun mounts constructed in 1943 for protection of the Portland Harbor area. The turf covered mound-like structures are the ammunition bunkers and the high cylindrical concrete towers housed range finders and were observation towers.

The Cape Elizabeth Formation, the basal unit of the Casco Bay Group is well exposed along the coast from Crescent

Beach to the west to Hunts Point to the north. It consists of fine to medium grained, brown to buff, graywacke to subgraywacke beds from one inch to one foot thick alternating with beds from less than one to six inches thick of dark grey micaceous phyllite. Quartz "knots" and veins are common within the unit. The relations between bedding, foliation and the two prominent joint sets, coupled with the small scale crumpling of the beds, give rise to the log-like appearance of the rock. (Tourists are convinced they are observing petrified wood.) Although the rocks are intricately crumpled into tight folds the regional dip is very gentle to the northwest. The base of the Cape Elizabeth Formation is not exposed in southern Cape Elizabeth and the total thickness of the unit exposed here does not exceed 500 feet.

These rocks exhibit the lowest metamorphic grade within the Casco Bay region. The assemblage quartz-muscovite-chlorite-albite-epidote (or calcite) is characteristic and biotite and garnet are totally lacking.

Return to park entrance.

36.4 Turn left onto Two Lights Road.

37.4 Turn right (north) onto Ocean House Road.

37.5 Bear right (east) onto Maine Route 77 and immediately turn right onto Broad Cove Road.

37.9 Turn right onto dirt road.

38.3 Turn left onto paved road.

38.3+ STOP NO. 2 Broad Cove

Park in field on the right side of the road and proceed to shore near the red shack.

Looking into Broad Cove from the shore the following units are exposed:

a) To the right (south) is Hunt's Point composed of the upper Cape Elizabeth Formation, similar but somewhat more argillaceous than the Two Lights exposure.

b) Within the cove itself are spotty outcrops of the Spring Point Greenstone. Here this unit is a green, fine grained chlorite phyllite with minor amounts of muscovite, quartz, albite, and epidote.

c) Immediately in front of the red shack is a recrystallized felsite dike.

d) Overlying the Spring Point Greenstone in small synclinal troughs within the cove, the basal beds of the Scarboro Phyllite are exposed. This unit is characterized by its high sulfide content giving rise to the extensive rusty weathering, the presence of graphite, the undulatory nature of the foliation, the abundance of quartz "knots", and the lack of arenaceous beds. To the north (left) the Scarboro Phyllite is continuously exposed to Trundy's Point, and within this exposure lies the biotite isograd. As has been observed occasionally in the Dalradian of Scotland, garnet rich in spessartine appears before biotite and can be observed within the Scarboro along the north rocky shore of Broad Cove.

Proceed north along paved road.

38.4 Turn left onto Edgewood Road.

38.6 Turn left onto Broad Cove Road.

39.2 Turn right (North) onto Ocean House Road (Maine Route 77).

39.3 Turn right remaining on Ocean House Road.

39.6 Turn right onto Trundy Point Road, passing through stone gate.

40.0 Continue straight ahead on Trundy Point Road.

40.2 Bear left onto Reef Road.

40.5 STOP NO. 3 Trundy Point

After rounding curve to the right pull off to the edge of the road and park.

Here the vertical beds of Spurwink Limestone are exposed forming the southern flank of a small syncline. To the south

are the upper beds of the Scarboro Phyllite and to the north in the core of the syncline the Jewell Island Phyllite is exposed.

The Spurwink Limestone is a medium grained, sandy limestone with biotite and almandine garnet present. The coarser beds are separated by thin beds of a more micaceous calcareous rock giving rise to a ribbon texture that is characteristic of the Spurwink Limestone throughout the Casco Bay Region. The unit averages about 100 feet thick although due to its plasticity during deformation it can vary from less than two feet to over 200 feet in thickness. It has been the most useful marker unit within the Casco Bay Group.

The Jewell Island Phyllite is nearly indistinguishable from the Scarboro Phyllite and is the Highest known unit of the Casco Bay Group.

From the core of the syncline at Peabbles Point north to Pond Cove the entire section from the Jewell Island Phyllite through the Cape Elizabeth Formation is exposed, making up the south flank of the Portland Head Light anticline. From Trundy Point on northward through Cape Elizabeth, South Portland, and Portland the rocks lie within the garnet isograd. Epidote and albite also occur within this region, thus, the rocks are characteristic of the upper greenschist facies (quartz-albite-epidote-almandine subfacies after Fyfe, Turner and Verhoogen, 1959).

Proceed south along Reef Road.

40.8 Turn right onto Waburn Road.

40.9 Turn left onto Trundy Road.

41.5 Turn right onto Ocean House Road.

42.5 Right turn onto Maine Route 77 (Ocean House Road).

42.9 Community of Pond Cove. Turn right onto Shore Road.

44.3 STOP NO. 4 Pond Cove

Pull off on left side of road and park. Walk across the road to the shore.

Here the basal beds of the Cape Elizabeth Formation and the upper portions Cushing Formation are exposed. The contact is gradational with interbeds of each lithology occurring within the other.

The Cape Elizabeth Formation is more severely deformed, of higher metamorphic grade, and contains much thicker and more massive sandstone beds than at the Two Lights exposures. In a number of the sandstone beds relict cross-bedding and graded bedding are discernable. Two hornblendite beds occur within the basal Cape Elizabeth Formation. It is believed that these represent the metamorphism of a dolomitic graywacke. The nearly complete absence of albite in the hornblende-quartz-epidote-almandine-biotite assemblages apparently precludes a basic igneous rock origin.

The Cushing Formation, underlying the Cap Elizabeth Formation, is believed to be a metavolcanic rock. It is a quartz-microcline-garnet gneiss. On the islands to the northeast where a considerably greater thickness is exposed relict textures indicative of tuffs and agglomerates are preserved; however, on Cape Elizabeth the rock is generally a massive gneiss with few palimpsest features. The augen, now microcline-muscovite, may be blastoporphyritic structures. A number of the upper beds within the Cushing Formation contain hornblende giving rise to the darker color of these beds.

Proceed northward on Shore Road.

45.2 Turn right (east) into Fort Williams. Continue past sentry post through gate.

45.5 Turn right at stopsign following directions to Portland Head Light.

45.7 STOP NO. 5 Portland Head Light

Here the typical upper portion of the Cushing Formation is exposed along the core of the Portland Head anticline. In the vicinity of the lighthouse several post-metamorphism diabase to basalt dikes are observed.

Retrace route back to the entrance to Fort Williams.

46.1 Turn right onto Shore Road.

47.1 Bear right onto Prebble Road.

47.7 Continue through Willard Square (stop sign and blinker) bearing right continuing on Fort Road.

48.0 Turn right onto Beach Street.

48.1 Turn right onto Mrytle Avenue.

48.2 STOP NO. 6 Willard Beach

Park at end of street and walk onto beach.

In Simonton Cove from Spring Point at the north to the small point enclosing the small harbor to the south the Spring Point Greenstone, Diamond Island Slate, Scarboro Phyllite, and the Cape Elizabeth Formation are exposed. A fault forms the southern end of cove where the Scarboro Phyllite, exposed at Willard Beach is juxtaposed against the Cape Elizabeth Formation forming the point at the southern end of the Cove. This fault can be traced for several miles to the southwest.

With the exception of the Spring Point Greenstone the lithologies are similar to those seen at previous stops. Garnet is present in the Cape Elizabeth and Scarboro Formations as well as albite and epidote, defining the metamorphism as upper green-schist facies. The Spring Point Greenstone here is a hornblende-chlorite-epidote rock with minor biotite and albite - the characteristic assemblage for a potash deficient rock subjected to this grade of metamorphism.

Turn around and proceed west on Myrtle Avenue.

48.3 Turn right onto Fort Road.

48.4 Turn left onto Pickett Street.

48.6 Turn left onto Broadway.

49.8 Turn right onto Cottage Road (Maine Route 77).

50.0 Bear right onto Ocean Street (Maine Route 77).

50.3 Bridge over Fore River (Maine Route 77) to Portland.

50.8 Turn right onto ramp off bridge (Maine Route 77).

50.9 Left turn onto State Street (Maine Route 77).

51.4 Longfellow Square. Continue on State Street (Maine Route 77).

51.6 Turn right onto Cumberland Avenue (Maine Route 26).

52.6 Turn left onto Washington Avenue (Maine Route 26).

53.5 Causeway over the Back Cove.

53.7 Bear right onto U.S. Route 1 and Interstate 295 ramp.

53.9 Merge into Interstate 295.

54.1 Bear right onto ramp from Interstate 295 to U.S. Route 1.

54.8 Bridge over Presumpscot River((U.S. Route 1), separating Portland and Falmouth.

56.2 Bear right off U.S. Route 1 onto Maine Route 88.

56.7 Turn right onto Waite's Landing Road.

57.1 On right a small outcrop of Pejepscot Formation which is megmatized and contains pegmatite bodies.

57.2 Approximate location of contact between Pejepscot Formation and Cape Elizabeth Formation.

57.6 STOP NO. 7 Waite's Landing, Falmouth Foreside

Park along road and proceed to shore.

Here again the Cape Elizabeth Formation is exposed showing a somewhat higher metamorphic grade. Quartz-biotite-oligoclase/andesine-muscovite are the major minerals with minor almandine and epidote/calcite present. Such an assemblage is typical for the lower almandine-amphibolite facies. No evidence of migmatization or pegmatite development is observed, and higher grade minerals such as sillimanite are not found.

One-half mile north of here at Princes and Bartlett Points the contact between these two units is separated by less than 100 feet of cover and on Sturdivant Island, two miles to the northeast, the cover over the contact is less than 20 feet wide. At both of these localities as well as here the migmatization, the occurrence of pegmatitas and the presence of sillimanite is restricted to the Pejepscot Formation. Farther to the northeast on Cousins and Littlejohn Islands, minor discordant pegmatites appear in the Cape Elizabeth Formation and on Mere Point about 12 miles to the Northeast, sillimanite is found in the Cape Elizabeth along with the pegmatite bodies.

The abrupt change in metamorphic grade, the abrupt occurrence of migmatization and pegmatization are the major factors that lead to the interpretation that this is a fault contact. The extent of the fault both to the southwest and the northeast is unknown and should be investigated.

Turn around and return to the juction of Waite's Landing Road and Maine Route 88.

58.5 Turn right from Waite's Landing Road onto Maine Route 88.

60.4 Turn left (west) onto Johnson Road.

60.8 STOP NO. 8 Johnson Road Quarry

Park along Johnson Road and walk along abandoned dirt road to the right about 200 feet into quarry.

This is one of the larger of several small granitic bodies that intrudes the Pejepscot Formation in this area. The rock is a medium grained, homogeneous, holocrystalline quartz-microcline-oligoclase-biotite granite. The contact with the gneiss is generally separated by pegmatite of variable thickness.

Return to cars and continue west on Johnson Road.

61.1 Turn right (north) onto U.S. Route 1.

61.6 STOP NO. 9 Riprap Quarry

Turn left onto dirt road into quarry and park.

Here the typical Pejepscot Formation is exposed as described at mileage 22.0. Note pegmatite relations, migmatization, and the "salt and pepper" texture of the biotite schist. Garnet (almandine) can be observed in the schist and microscope sillimanite is present.

Return to cars and proceed north on U.S. Route 1.

68.4 Casco Bay Motel.

END OF TRIP.

d) There is a lack of igneous lamintaion (parallelism of plagioclase grains).

Other mechanisms might be 1) periodic release of pressure and volatiles from the magma chamber, as it might affect the rates of nucleation of the dark versus light minerals; 2) periodic undercooling combined with vigorous currents in the magma as envisioned by Taubeneck and Poldervaart (GSA Bull, Vol. 71, pp. 1295 and 1322) for the formation of "Willow Lake-type layering" in the Willow Lake intrusion, Oregon; 3) formation of concentric planes of easy migration of interstitial liquid in the last stages of consolidation of the magma.

4. Contact of Cortlandtitic gabbro apophysis with very anorthositic gabbro. No chilling of the former against the latter indicates that the cortlandtitic gabbro was intruded before the normal gabbro - anorthositic gabbro had cooled down.

5. Very interesting zone where the normal gabbro does not grade into anorthositic gabbro. In the normal gabbro note the graded layering with the mafic concentrations in each layer toward the outside. The graded layering here occurs at about the same "horizon" as mentioned in note 2. Most conspicuous of the structures are the series of slabs of very strongly banded gabbro intermediate between typical anorthositic gabbro and normal gabbro. On the inner side of these slabs is typical anorthositic gabbro. Layering of the slabs resembles to some extent the "horsetail" vein structures noted in metallic mineral deposits. It is the present belief of the writer that these layers are in some way mechanically formed. They can hardly be ascribed to the action of currents within the magma chamber cutting and filling earlier formed gabbroic material. Note the "crow foot" development of augite crystals always oriented toward the center of the complex at the boundaries of the slabs.

6. Normal gabbro; some zones of fine-grained poikilitic gabbro and pegmatitic clots.

7. Contact zone of normal gabbro with the Kittery Formation. Note strong fracturing and recrystallization at contact, of both the Kittery Formation and dikes within the Kittery. Contact metamorphic affects decrease rather rapidly away from the contact. Blue color of Kittery phyllite interbeds close to contact indicates the development of considerable amount of cordierite. Diabase dikes were fractured in a more brittle manner than the Kittery Formation and are extensively injected by small dikes and veins of buff-colored granodiorite derived from the last stages of crystallization of the gabbroic phases. Note the possible remobilization of portions of the Kittery beds and injection into fractures in the diabase dikes. Note the pocket of olivine-rich, chilled phase of the gabbro.

8. Here can be seen the relations of the apophysis of cortlandtitic gabbro, anorthositic gabbro and central funnel of cortlandtitic gabbro. Layering in the anorthositic gabbro southwest of the apophysis dips away from the center of the complex rather than toward -- this being one of the few areas where an outward dip is observed. Layering in the apophysis of cortlandtitic gabbro argues against differential crystal settling origin of the layering.

9. Contact area of the central mzss of cortlandtitic gabbro and anorthositic gabbro. Cortlandtitic gabbro at the margin is quite mafic.

10. Relatively dark, mafic cortlandtitic gabbro.

11. Rather feldspathic phase of the Cortlandtitic gabbro near the center of the body.

12. Relatively mafic cortlandtitic gabbro, not too far from concealed contact with anorthositic gabbro.

13. Almost the same as noted at 11, maybe a little more mafic.

14. NO HAMMERING HERE, PLEASE! Most mafic phase of the cortlandtitic gabbro noted.

15. Small but rather significant exposure of cortlandtitic gabbro with block of anorthositic gabbro indicating that the cortlandtitic gabbro is a product of a later intrusion of magma than that which formed the normal and anorthositic gabbros.

Return to the vehicles in the parking lot. Road log to the next locality given below.

Mileage	
0.0	Parking lot overlooking the Cape Neddick Lighthouse.
0.1	At the parking area exit turn left onto "Broadway".
1.1	Right onto 1A and follow through to York Beach Village.
1.5	Right on 1A bearing slightly left in about 400 feet.
2.1	Keep straight (1A bears left).
2.4	Park opposite entrance to picnic grounds, in the parking lot of the lobster pound and restaurant on the south side of the Cape Neddick River.

Walk down the picnic grounds lane to the shore. Contact of the Kittery Formation and alkaline granite of the Agamenticus Complex is exposed along the shore at the end of the lane.

Note several dikes of basalt or diabase cut through granite stringers and the main mass of the granite. Several other dikes in the Kittery Formation on the opposite shore cut apophyses derived from the alkaline granite. Nowhere has the reverse (alkaline granite cutting diabase or basalt) been observed.

Note carefully some of the minor granite stringers -- granitizationists will be very happy here. Non-dilation can be demonstrated!

This is the end of the formal trip. For those who can stay longer, the leader will be happy to conduct an informal tour of features exposed on the Nubble.

To return home, retrace route to 1A, then hard right on 1A to junction with Route U. S. 1. Southbound people follow Route 1 to Kittery where U. S. 1 feed directly into the Kittery By-pass and the Interstate Bridge. Northbound people take Route 1 to Wells Corner following signs to the Maine Turnpike Wells entrance (the same route travelled from Brunswick to the assembly point).

TRIP H

Geology of the Kezar Falls - Newfield Area, Maine

Leader: Richard A. Gilman, Fredonia State College,
Fredonia, New York.

INTRODUCTION

During the summers of 1962-1964 the writer has carried out field work in the Kezar Falls-Newfield-Buxton areas as part of the mapping program of the Maine Geological Survey. The purpose of this program has been to examine the major stratigraphic and structural relationships in an area previously unmapped. Mapping in adjacent areas has been done by Hussey in southern York County, Quinn in the Wolfeboro, N.H. quadrangle, and by Wilson in the Ossippe Lake, N.H. quadrangle.

The region is underlain by schists and migmatites in the sillimanite zone of regional metamorphism and by granitic bodies of the New Hampshire and White Mountain magma series.

The Rindgemere formation, believed to be correlative with the Littleton formation, has been divided into three major lithic types: (1) pelitic schists and migmatites with the general mineral assemblage of quartz-feldspar-biotite-muscovite-garnet-sillimanite, (2) rusty weathering quartz-feldspar-sulfide schists, and (3) well bedded grey-green calc-silicate granulite. The Berwick formation is exposed in the eastern part of the area and is consistently a grey, granular, quartz-feldspar-biotite granulite (granulite refers to texture only).

Intrusive rocks tentatively assigned to the New Hampshire plutonic series are represented by muscovite-biotite granite and a foliated biotite quartz-monzonite to quartz-diorite. Both of these units are commonly cut by pegmatites. Rocks of this series are abundant and will be seen on this trip. Rocks belonging to the White Mountain plutonic-volcanic series are represented by several isolated stocks in the Kezar Falls and Newfield quadrangles. These are mostly syenites and granites, but volcanics are also present on Burnt Meadow Mountain. These have not been cut by pegmatites. None of these stocks are easily accessible and will not be seen on this trip.

The predominantly northeast trending structures of Southern Maine are replaced by northwest trends in much of the Newfield-Kezar Falls area. The structural pattern is complex and has not as yet been completely studied. The northeast trending folds of the Berwick formation plunge southwesterly below the pelitic schists of the Rindgemere formation. Mapping of the

structure has been based on both schistosity (which in many places can be shown to be parallel to bedding) and bedding, especially in the calc-silicate granulite. As yet no clear regional pattern of folding has evolved, but the structures at individual outcrops suggest the following conclusions concerning the type of deformation.

A) The schistosity, which is probably parallel to bedding in most instances, has been folded.
B) The lack of consistent trends of fold axis suggests multiple folding.
C) The occurrence of folds with nearly horizontal axial planes, the predominance of gentle southwesterly dips, and numerous exposures of overturned beds suggest a fold pattern involving northwest trending folds with axial planes dipping gently to the southwest.

Quadrangle Maps Needed :

Kezar Falls, Sebago Lake, Newfield, Buxton 15' quadrangles.

Assembly Point

Town Hall, Limington, Maine
at junction of State Routes 11 and 117.

Time

9:15 a.m. SHARP, from Town Hall. If you arrive late, follow directions to first stop. Allow 1 hour and 15 minutes driving time from Brunswick to Limington.

Directions to Reach Assembly Point

Take Interstate 95 (U. S. Route 1 part of the way) to the Falmouth entrance of the Turnpike. Leave Maine Turnpike at exit 8 (Portland-Westbrook). Turn left beyond the turnpike booth following signs to juctions with Route 25. Make right turn on Route 25 and follow through Westbrook, Gorham, and Standish to East Limington. At East Limington (59.6 miles from Bowdoin Campus) turn left on Route 11 and proceed to junction with Route 117 in Limington. Town Hall is on the corner at this junction. LEAVE AS MANY CARS HERE AS POSSIBLE. THE TRIP WILL END AT THIS POINT.

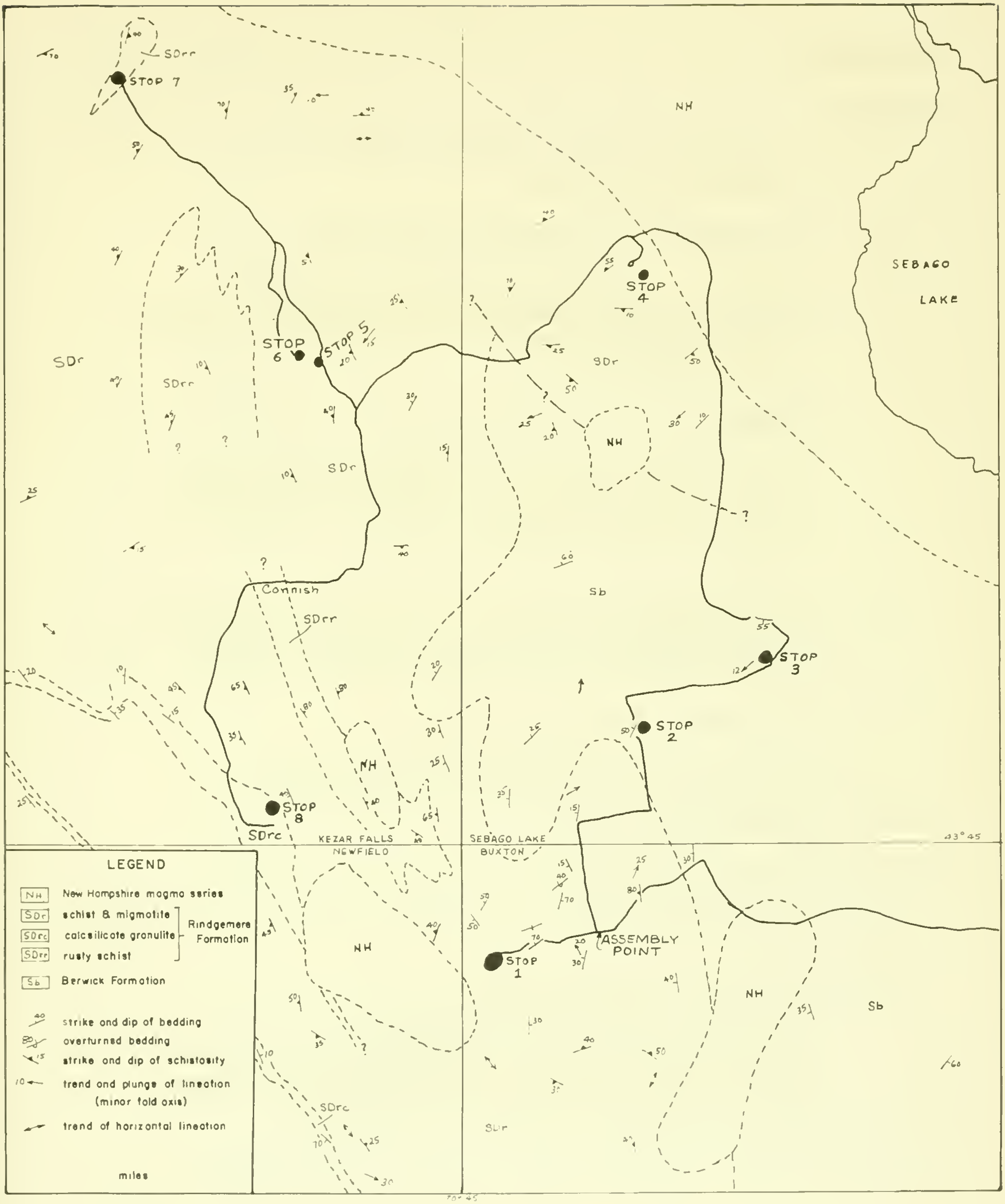

FIGURE 1. GEOLOGIC SKETCH MAP OF THE CORNISH AREA.

ROAD LOG

Mileage

0.0 Town Hall parking lot, Limington, Maine.
Proceed west on Route 11.

0.1 Go straight on tar road (Route 11 bears left).

1.5 STOP #1. Lower Part of Rindgemere Formation
Park cars and enter apple orchard through gate. The rock here is fairly well-bedded mica schist with conspicuous porphyroblastic knots.

Notes:

1) Andalusite, staurolite, and sillimanite are present in this rock; it is therefore of lower metamorphic grade than most of the rocks in the Kezar Falls - Newfield area which contain only sillimanite.

2) This unit, which tends to be more aluminous than most of the Rindgemere Formation, may represent the lower part of the Rindgemere, and may be equivalent to the Gonic Formation in the Lebanon-North Berwick area (Hussey, 1961).

Turn around and return to Limington.

3.6 Junction of Routes 11 and 117. Left turn on 117.

6.3 Right turn on tar road.

7.1 Right turn onto Route 25.

7.4 Left turn on tar road.

8.7 STOP #2. Berwick Formation?

Park cars as far off road as possible.
Exposed in roadcut here is well-bedded mica schist and quartzitic schist showing folded schistosity and excellent graded bedding indicating tops to the southeast.

Notes:

1) This unit is probably transitional between Berwick Formation (quartzitic) and the pelitic schists of the Rindgemere Formation.

2) Note the orientation of mica flakes in different beds. Some are parallel to the bedding-schistosity; others are parallel to the axial planes of the folds.

3) Lenses of gray-green calc-silicate granulite seen here are quite common in the Berwick Formation.

4) The axes of folds of the schistosity commonly trend northeast and have gentle plunges. A problem for future study is the age relationships and trends of different generations of folds.

Continue on tar road.

9.2 Right turn at 4 corners.

11.5 Left turn onto Route 11. Proceed across bridge and park off highway. STOP #3. Steep Falls, Berwick Formation.

Notes:

1) The rock exposed here is primarily a well-bedded, fine to medium-grained gray biotite-quartz feldspar granulite. Biotite flakes in most cases lie parallel to bedding and in some cases there is a good lineation developed in biotite aggregates. The granulite is cut by granite (also showing a foliation) and pegmatite, the pegmatite being the younger. The rock does not appear to be severely deformed, but small stringers of quartz are highly contorted in some instances.

2) At the west end of the exposure, at water's edge, numerous thin lenses of gray-green calc-silicate granulite are found. These are fairly common in this biotite granulite of the Berwick Formation.

3) Graded bedding may be seen in some places. It is observed as a change from coarser-grained quartz-feldspar material grading upward to finer-grained, micaceous rock. This suggests that the unit is rightside up at this outcrop.

4) Rocks of this lithology are consistently found to the east of the pelitic schists. The contact is placed where this

lithology becomes the predominant rock type. The contact is believed to be gradational.

Continue on Route 11.

12.0 Left turn on Route 113.

13.5 Right turn on Route 107.

15.4 Bear left on 107.

18.8 Road from the right (they have the yield); be ready for left turn.

19.2 Left turn onto Douglas Hill Road.

20.1 Sharp left turn. At this point, crowd into as few cars as possible. Parking is very limited at Stop #4.

20.4 STOP #4. Douglas Hill, Rindgemere Formation.
Park cars in public parking area. Walk up path to top of Douglas Hill. Beautiful view of Sebago Lake and the White Mountains.

The excellent exposures on the top of Douglas Hill are typical of most of the sedimentary rocks of the Kezar Falls-Newfield area. These are similar to rocks of the Rindgemere Formation in the Berwick Quadrangle mapped by Hussey (1962) and Katz (1917). They are considered to be correlatives of the Lower Littleton Formation of eastern New Hampshire.

Notes:

1) The rocks are characterized as coarse-grained garnet-mica schists and migmatites. Quartz veins and pods are numerous, and the migmatite is cut by pegmatite.

2) The foliation maintains a general N 70 E strike with a moderate to steep northerly dip. The schistosity has been folded with fold axes plunging to the northeast.

3) Most of the area to the east is underlain by the Sebago pluton (mostly biotite-muscovite granite to quartz monzonite).

Turn around; return down tar lane to Douglas Hill Road.
Pick up cars.

21.1 Left turn on Douglas Hill Road.

21.2 Bear left at "Y".

22.6 Bear left onto tar road.

24.8 Bear left.

26.8 Right turn onto Route 5.

27.7 STOP #5. Lunch. Turn left off Route 5 into State Highway Commission picnic ground. Good view of the Hiram Falls hydroelectric plant on the Saco River. Stop #6 will be at the foot of the dam on the other side of the river.

Continue north on Route 5.

29.9 East Hiram. Go left, crossing the Saco River. Make left turn immediately after the bridge.

30.1 Keep straight.

32.0 STOP #6. Hiram Falls, Rindgemere Formation. Park cars in parking area. Follow path to the ledges at the foot of the dam.

Notes:

1) The outcrops below the dam are of two types of metasediments, pegmatite, and diabase dikes. Large blocks of migmatite are enclosed in pegmatite and have apparently been rotated. In the overflow channel, a well-bedded granular schist is exposed. It has been folded and ptygmatic folds are observable in some places. The beds are graded, but a consistent top direction is difficult to determine.

2) Potholes are well-developed here and some of the ptygmatic folds are best exposed on the sides of these potholes.

3) In much of the Kezar Falls quadrangle the Rindgemere Formation is migmatite with randomly oriented "spangles" of muscovite. Well-bedded mica schist becomes more abundant in the northern portion of the Newfield quadrangle (Stop #8).

Return to Junction with Route 5.

33.9 Straight on Route 5.

38.4 STOP #7. Rusty and Non-rusty Schists of the Rindgemere Fm.
Two exposures are seen in roadcuts along the west side of Route 5. The southern outcrop is of a rusty medium-to-coarse grained quartz-mica schist with pyrite. The northern exposure is of fairly typical poorly-bedded schist and schistose quartzite. The bedding is parallel to schistosity, but both are deformed and an eastward plunging fold is present.

Turn around. Follow Route 5 to Cornish.

46.6 Route 5 turns right to Cornish.

48.7 Right turn onto Routes 25 and 5.

49.4 Left turn on Route 5, just west of Cornish business district.

53.2 Left turn onto gravel road; becomes tar road in 0.2 mile.

53.7 STOP #8. Calc-silicate and Associated Schists of the Rindgemere Formation.
Park at first farmhouse, walk up woods road and climb southwest side of Pease Mountain.

Notes:

1) This is one of the better exposures of this unit in the area. Commonly only a few feet of section are exposed, but it is presently believed that the zone containing most of the calc-silicate is on the order of 100 to 200 feet thick.

2) Minerals of the calc-silicate include diopside, grossularite, idocrase, calcite, quartz, sphene, and plagioclase.

3) The rocks associated with the calc-silicate are granular biotite schist, and a muscovite-biotite-garnet-sillimanite schist in which the muscovite and sillimanite are oriented in the schistosity plane. This is usually referred to as a "whispy schist" as opposed to the "spangled schist" and migmatite seen earlier.

Return to cars; return to Route 5.

54.1 Left on Route 5.

54.3 Berry's Ledge (roadcut) on right. Noted idocrase-scheelite-grossularite locality in punky weathering calc-silicate. Extreme contortion of bedding is well demonstrated here.

59.2 Left turn on Route 11 in Limerick Village.

66.2 Town Hall parking area in Limington. END OF TRIP.

TRIP I

EOLIAN FEATURES IN FREEPORT AND WAYNE, MAINE

Leader: D. W. Caldwell, Dept. of Geology, Wellesley College.

Introduction.

The purpose of this trip is to examine certain eolian features of south central Maine. Other than dunes in coastal regions and on the shores of some lakes, eolian features in this section are of two principal types: 1. Active sand dunes developed on deposits of outwash sand as the result of the destruction of the stabalizing soil and vegetation cover. Although the soil cover on these sand deposits is poor at best, man has contributed to the erosion of the soil through overcultivation and overgrazing. The Desert of Maine (Stop 1) is a feature of this type. 2. "Fossil" deposits of windblown sand which were formed shortly after deglaciation of the area. Sand dunes and sheets of windblown sand became stabilized by a soil and vegetation cover at some time following their deposition. "Fossil" dunes of this type range in size from small hummocks a few feet high to large transverse dunes several miles long and more than 20 feet high (Caldwell, 1959, 1960). The Desert of Wayne, Maine (Stop 3) consists of a deposit of "fossil" windblown sand which has recently been reactivated.

A third type of eolian deposit in this area is a layer of silt which occurs in the A horizon of many of the soils of the region. This silt has been ascribed to wind deposition by many workers in New England and has been classified as loess by some (Smith and Fraser, 1935). Observations by Lyford (1963) suggest that at least some of this presumed wind-deposited silt may be the result of the activities of ants. According to Lyford, ants may return an inch of fine sand and silt to the surface in 250 years or a foot or more in 3,000 years.

Road log for Trip I.

Approximate number
of miles from start.

0	Assemble at designated point on Bowdoin College campus.
1	Turn left to Interstate 95 and U. S. 1.

8 Turn right to Desert Road.

10 Desert Road to Desert of Maine, Stop 1.

Stop 1. The Desert of Maine

Introduction. The Desert of Maine is without doubt the best known sand deposit in New England. It now consists of several tens of acres of drifting sand which became active about 50 years ago. The source of the sand is a glacial outwash deposit which is exposed near the center of the Desert. A strong oxidized zone on the outwash approximately marks the pre-Desert land surface.

The winds effective in moving sand are from the north and northwest. In a seven-year period, the sand encroached six feet southward into a wooded area (Trefethen, 1949 and Allen, 1955). During the same period measurable wind erosion occurred in the central part of the Desert.

The tour will leave from the parking lot and proceed through the entrance building (the management of the Desert of Maine has graciously invited members of the Conference to be their guests on this tour). The barn beside the entrance building is built on the pre-Desert land surface. Dunes from 10 to more than 20 feet high have been built on this surface.

In a 100 to 200 foot-wide strip running north-south through the central part of the Desert, up to 10 feet of erosion has occurred. The oxidized zone of the pre-dune soil surface is exposed, or only thinly covered, along the eastern and southern part of this strip. A layer of fine sand and silt in the underlying outwash is exposed in much of the central part of the Desert. Below the fine sand and silt, the outwash sediments consist of gravelly sand. Small pebbles and granules from this sediment are wind-polished and form a kind of minature desert pavement.

In parts of the central blow-out, the land has been eroded to or almost to the water table. Soil moisture remains in these parts for periods long enough to allow mosses, lichens and fungi to become established. Pine, birch and cherry trees subsequently become seeded on the moss-covered surface and these portions

of the Desert become stabilized.

A spring house near the eastern margin of the drifting sand has been completely buried during the past 20 years. Beyond the spring house, a small stream has effectively stopped migration of sand dunes toward the east.

At the southern edge of the Desert, the sand deposited by wind action is more than 40 feet thick. In this area of the Desert, the very tops are all that are exposed of several large trees. According to Allen (1955), the area of the Desert becoming stabilized by natural reforestation is approximately equal to the area being lost to drifting sand.

On returning through the entrance building, notice the specimens of fulgarite collected from the Desert.

Return to cars and proceed back along Desert Road.

10.5 Turn left on Merril Road.

11.0 Turn right on Hunter Road.

11.2 Turn left on Murch Road.

11.7 Turn Right on Pownal Road.

13.2 Bear left to Routes 125 and 136. Presumpscot Formation of Bloom (1960) on right.

14.0 Turn right on Route 125.

23 Turn right over Androscoggin River to Lisbon Falls and Route 9.

24 Bear right on Route 9.

32 Turn right at Drinkwater Corner. Note Kettle Lake on left.

33 Cross Route 126 to Route 132.

37 Turn left at Wales Corner, toward Leeds Junction and Keenes Corner. Near Leeds Junction, the outwash plain has a few

inactive, "fossil" dunes. The similarity of the degree of weathering on these dunes and the surrounding sand plain suggests a similar age for both features. If this similar soil development is pertinent to the question of age, these and similar "fossil" dunes in this area were formed shortly after the deposition of the outwash sand and are not stabilized forms of more recently active dunes of the type seen at the Desert of Maine.

40 Turn right on U. S. 202.

40.75 Turn left on Route 106.

42. Leave Lewiston Quadrangle and enter Livermore Quadrangle. From just north of concrete mix plant to Curtis Corner, the road follows the crest of an esker. This esker may be traced for more than 25 miles northward, across the Livermore Quadrangle and into the Farmington Quadrangle (Caldwell 1953, 1959).

46.5 Stop 2. Leeds, Maine.

This stop has nothing to do with eolian features, but is interesting enough that a brief stop here is justified.

The outlet of Androscoggin Lake is by way of the Dead River to the Androscoggin River (see Livermore Quadrangle, Maine). During periods of high discharge, the Androscoggin River reverses the flow of the Dead River back into the Androscoggin Lake. Sediments deposited in the lake during these periods of reversed flow have formed the large delta at what is normally the outlet of the lake. This delta may be seen on the Livermore Quadrangle map and from the vantage point at stop 2.

The drainage conditions which allow the formation of this "reversed" delta likely have existed since the emergence of this area from the sea about 12,000 years ago. However, the present rate of delta formation can not be used to estimate the age of the delta because a dam constructed near the mouth of the Dead River has influenced the sediment load in the river. This ingenious device, known locally as "the flip-flop dam", normally controls the flow of water in the Dead River into the

Androscoggin River. Wshen the Androscoggin River is flooded, the dam automatically reverses itself and controls the flow of water in the Dead River into the Androscoggin River. When the Androscoggin River is flooded, the dam automatically reverses itself and controls the flow of water from the Androscoggin River into Androscoggin Lake.

A further interesting feature of the Dead River is the occurrence in its waters of the freshwater hydroid, Craspedacusta sowerbii, that passes through a reproductive cycle which includes a medusa stage. It is an unnerving experience for one such as this writer, who was unaware of the existence of freshwater jellyfish, to see hundreds of these creatures, 2 to 3 cm. in diameter, pumping themselves through the water. According to Lytle (1960), C. sowerbii is indigenous to the Yangtze River basin in China and may have been introduced into this country with certain oriental water plants. As far as this writer knows, this is the first reported occurrence of C. sowerbii in Maine and only the fourth in New England.

48.0 Bear right along the shore of Androscoggin Lake. Hedgehog Hill (see Livermore Quadrangle, Maine) is formed of a coarse grained border phase of a nearly circular stock of gabbro which underlies Androscoggin Lake. Erratic boulders from this stock form a boulder train to the southeast of this area. Boulders of this gabbro occur along the left side of the road in the vicinity of the colony of summer camps.

50 Turn right on Route 219.

51.5 Turn sharp left on Route 133.

53 Turn right near crest of hill through what appear to be the gate-posts of a driveway.

53.5 Stop 3. The desert of Wayne, Maine.

Introduction. In appearance, the desert of Wayne is very much like the Desert of Maine (stop 1). Present here are fields of drifting sand, dunes, ripple marks and trees buried by sand. Sand has been drifting in this area since the memory of (interviewed) man runneth not to the contrary (a period which

covers the past 70 years). Many local residents are of the opinion that sand-free pastures existed here about 100 years ago.

The source of the sand in the Wayne area is unlike that of the Desert of Maine, where, it will be recalled, outwash sand became windblown during the past 50 years. Evidence seen by this writer suggests the sand in the Wayne area was derived from the sand deposits bordering the Androscoggin River, 3 to 4 miles to the west. It seems likely that this sand was wind-transported to its present location shortly after the area emerged from the sea some 12,000 years ago and before enough vegetation and soil cover existed to prevent extensive wind action. After deposition of this sand, the development of a soil and vegetation cover may have stabilized the sand until about 100 years ago. The evidence upon which this origin is postulated is as follows:

1. The lack of any known stratified drift deposits in this area at elevations great enough for the Wayne sand to be simply reworked stratified drift.

2. The occurrence in the Androscoggin River valley of sand deposits of the proper texture that they could be considered as the source of the Wayne sands.

3. The occurrence of a continuous layer of sand on the west-facing hills on which the Wayne sands are deposited.

4. The occurrence of the thickest deposits of sand on the lee side of these hills (the east side, assuming the effective wind to be from the west or northwest).

5. The extreme uniformity of the sand. The median diameters of 20 samples range from 0.4 to 0.7 mm. and the Trask sorting coefficients range from 1.25 to 1.40.

6. The occurrence near the summit of the hill of numerous wind-polished boulders. The boulders are derived from the underlying till. The polished surfaces face westward, an orientation which is consistent with the view that the sand in the Wayne area was wind-transported from the Androscoggin River sand plain by west or northwest winds.

Leaving the cars, the tour will proceed along a woods road to the crest of the hill where the wind-polished boulders occur. Also of interest in this area are numerous wind-polished pebbles and cobbles, some with poorly developed faceting. These smaller rock fragments, like the wind-polished boulders, are from the underlying till. There also exists here a thin veneer of wind-polished, granule-sized fragments which form a desert pavement of the type seen at the Desert of Maine.

It is interesting to speculate on how long the wind-polished surfaces on the boulders have been exposed to weathering. If one accepts the view proposed here that the transport of sand from the Androscoggin River valley occurred approximately 12,000 years ago, it then follows that the polished surfaces were also formed at that time. Although there is little data available concerning the length of time a bare rock surface may withstand chemical and mechanical weathering, one feels, intuitively anyway, that it could not be of the order of 12,000 years. It has been the writer's experience that only on recently exposed bedrock surfaces are glacial polish and striations preserved. This suggests that the wind-polished boulders in the Wayne area may have been buried by sand shortly after the formation of the polish and exposed to weathering only during the last 100 years. On the other hand, Bryan and Albritton (1942) conclude that wind-polished rocks studied by them in the Trans-Pecos region of Texas have been exposed to weathering for at least 5,000 years.

From the area of the wind-polished boulders, the tour will proceed eastward across several tens of acres of active sand.

In a pit near the eastern edge of the sand, cross-bedding is exposed. In one part of this pit a weak soil developed on bedded sand is overlain by sand with identical bedding characteristics.

To return to Maine Turnpike, etc: Continue for about 1 mile. Turn right toward Wayne and Route 133. Follow Route 133 left to Winthrop and U.S. 202. At Winthrop one may take U. S. 202 northward to Augusta (10 miles) and the Maine

Turnpike or U. S. 202 southward to Lewiston (18 miles) and enter the turnpike there. Both routes take about the same length of time; the Lewiston route is shorter (15 miles) and cheaper (50 cents). From Winthrop, the driving time to Boston is about 3 1/2 hours.

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TRIP K

Geology of the Buckfield and Dixfield Quadrangles in Northwestern Maine

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INTRODUCTION

This trip will study the Silurian and Devonian rocks on the southeast limb of a major northeast plunging syncline. All the rocks seen are in the sillimanite and staurolite zones of metamorphism. The stratigraphic nomenclature developed by Billings and his co-workers in New Hampshire was originally used in this area. However after detailed mapping by Fisher (1962), Guidotti (1965), Pankiwskyj (1964), and Warner (in preparation) in respectively the Bethel, Bryant Pond, Dixfield, and Buckfield Quadrangles, a new set of stratigraphic names was developed. Although these names are not yet official, we use them here as a matter of convenience. A geologic map appears in Figure 1.

Stratigraphy

The stratigraphy to be seen is shown in Table 1.

BUCKFIELD GROUP. This package of conformable formations is composed of sillimanite-biotite rich schists and calc-silicate granulites. The Buckfield Group has been traced northeast into the large pluton in the Farmington and Norridgewock Quadrangles. To the northeast of the pluton is found a large section of the "sandstone fancies" which will be discussed in a later section. The Buckfield Group has been traced through the Bryant Pond, Poland and Lewiston Quadrangles, into the Sebago Pluton. On the south side of this pluton, similar lithologies are found in the Eliot Formation of Hussey (1962 and unpublished 1963 map).

The Buckfield Group is correlated with the Waterville Formation of Osberg (in press), which contains graptolites of Wenlock (Middle Silurian) age. This correlation is based on lithologic similarity and the presence of a major anticline through the Livermore Quadrangle, evidence for which is not as yet conclusive. However, it is possible that the lithologic types may be traceable continuously from Buckfield, through the Poland, Lewiston, Gardiner, and Augusta Quadrangles to the Waterville area. Caldwell, who is mapping the Livermore Quadrangle and one of the writers (JW) both agree on an anticline in Livermore, but they disagree on the location of the axis.

TABLE I

Age		Pelite Facies	Sandstone Facies
Devonian		Temple Stream Fm.* Saddleback Mtn. Fm.*	Staples Pond Fm.*
Devonian or Silurian	Woodstock Group	Severy Hill Fm.* Peru Fm.* Newton Hill Fm.* Thompson Mtn. Fm. Anasagunticook Fm.*	Ludden Brook Fm.*
Silurian	Buckfield Group*	Moody Brook Fm. Berry Ledge Fm. Noyes Mtn. Fm. Patch Mtn. Fm. Turner Fm.*	

* - Unpublished and unofficial stratigraphic names.

Turner Formation. This unit is composed of sillimanite-biotite-muscovite-garnet schist with many zones and beds of biotite quartzite and biotite metagraywacke. A thin zone of graphite schist has been mapped by Caldwell.

Patch Mountain Formation. This is a thick unit (about 1000 feet) composed of marble and/or calc-silicate granulite interbedded with biotite-quartz granulite and/or biotite quartzite. The individual layers are between 2 and 10 cm. thick. The calc-silicate and marble make up between 50 and 80 percent of the unit. In the vicinity of North Turner, however, the amount of calc-silicate and marble is lower (about 30 percent). In the vicinity of Buckfield there are several lenses of two-mica schist.

Noyes Mountain Formation. Like the Turner Formation, this unit is composed of sillimanite-biotite-muscovite-garnet schists with zones and beds of biotite quartzite. Knots of sillimanite are very common in the schists. They are as large as 2.5 cm. across and weather out as white spots. The field name for this lithology, "maggot schist," is a result of these white sillimanite knots.

Berry Ledge Formation. The Berry Ledge, like the Patch Mountain, is composed of marble and calc-silicate granulite interbedded with biotite-quartz granulite. Guidotti (1965) states that the Berry Ledge contains more calcite than the Patch Mountain in the Bryant Pond Quadrangle. This generalization does not hold up in the Buckfield region. Unlike the Patch Mountain, the Berry Ledge is only about 200 feet thick. The difference in thickness is the key to distinguishing the two calc-silicate formations.

Moody Brook Formation. This unit is composed of sillimanite-biotite-muscovite schists. There are beds and zones of calc-silicate granulite and others of biotite quartzite in the unit. One thin lens of graphite schist has been mapped in the southwest part of the Buckfield Quadrangle. The discontinuous horizon of calc-silicate granulite in the Moody Brook appears to coincide with one of the discontinuous calc-silicate horizons in the Anasagunticook Formation. In several places, e.g., the Spruce Hills in the west part of the Buckfield region, the Moody Brook contains sulfide and is slightly rusty-weathering. The rusty zones do not seem to be stratigraphic.

WOODSTOCK GROUP. This package of conformable formations is composed of rusty- and gray-weathering, well- and poorly-bedded spangled-muscovite schists and gneisses. Cyclically bedded schist and quartzite is found at the top, and small lenses of calc-silicate granulite are found throughout the group. The schists of the Woodstock Group are rich in muscovite and feldspar, and commonly contain muscovite spangles, whereas those of the Buckfield group are rich in sillimanite and biotite.

To the west the Woodstock Group has been traced through the Bryant Pond, Rumford and Bethel Quadrangles into the gneisses of the Littleton Formation in New Hampshire. To the northeast, i. e., in the Buckfield, Dixfield, Livermore, and Farmington Quadrangles, the Woodstock Group thins considerably and, at least in part, is replaced by the "sandstone facies" which is found to the northeast. The Ludden Brook Formation is considered to be a southwestward extension of the sands. Figure 2 is a restored cross-section of Northwestern Maine, illustrating the relations within the Woodstock Group.

The Woodstock Group underlies the Devonian (?) Saddleback Mountain Formation, and overlies the Silurian Buckfield Group. It is thought to be of Devonian or Silurian age. Note that several mapped formations in the Woodstock Group will not be seen on the trip and are not discussed below.

Anasagunticook Formation. This unit is composed of coarse-grained spangled muscovite-sillimanite-feldspar-biotite-garnet schist and migmatized gneiss. To the northeast, where the metamorphism is less intense, this unit is well-bedded. Several lenses of calc-silicate granulite have been mapped. As has already been noted, the lowest horizon of these calc-silicate lenses seems to be continuous with a similar horizon in the Moody Brook Formation. This relationship is highly suggestive that the upper part of the Buckfield Group is in facies relation to the lower part of the Woodstock Group.

Thompson Hill Formation. In the Farmington Quadrangle this unit is composed of two parts. The upper contains sulfidic, rusty-weathering mica schist, muscovite schist, and quartzite, in beds ranging in thickness from 1/2 cm. to 1/2 meter. The lower part contains bedded argillaceous sandstone and pelite. To the southwest, in the Dixfield Quadrangle, the lower part of the formation is discontinuous, and farther on in the Buckfield Quadrangle it is altogether absent. The sandstone and pelite are found in beds from a few centimeters to 1 meter thick. The ratio of sandstone to pelite averages 1:1 in the Buckfield Quadrangle, 3:1 in the Dixfield Quadrangle, and as much as 8:1 in the Farmington and Norridgewock Quadrangles. This reflects the coming in of the "sandstone facies" to the northeast.

Newton Hill Formation. This unit is composed of cyclically bedded schist and quartzite. The individual layers are 2 to 15 cm. thick. The beds are graded in many places. Abundant pods of calc-silicate granulite are found near the top of the unit. The Newton Hill is found as discontinuous (?) lenses at the top of the Woodstock Group.

Ludden Brook Formation. This unit is composed of fine-grained to medium-grained biotitic-feldspathic sandstone and minor micaceous

sandstone, with pods, beds, and stringers of calc-silicate. Biotite laminae spaced from 1 to 10 mm. apart are common. The Ludden Brook is traced southwest as far as the northeast border of the Buckfield Quadrangle, where it interfingers with gneisses of the Woodstock Group. To the northeast it has been traced by one of the writers (KAP) as far as the village of Brownville in Piscataquis County. This unit is considered to be one of the tongues of the "sandstone facies".

Peru Formation. In the west part of the Dixfield Quadrangle this unit is composed of thinly-bedded calc-silicate (locally marble) and biotitic granulite in the west part of the Dixfield Quadrangle, but grades into biotitic granulite with pods of calc-silicate in the east part of the Dixfield Quadrangle. Farther to the northeast in the Farmington Quadrangle it is a calcareous sandstone interbedded with minor calcareous slate.

Although the map pattern of the base at the Peru Formation looks suggestive of an unconformity, we believe it is conformable. In several places the Woodstock Group has been observed grading into the Peru. We believe the map pattern is caused by the eastward thinning of the Woodstock Group.

Severy Hill Formation. This formation is composed of sulfidic, rusty-weathering quartzite, muscovite schist, and mica schist. These are interbedded in a manner reminiscent of the upper part of the Thompson Hill Formation. The Severy Hill Formation is continuous from the south part of the Dixfield Quadrangle, across the Farmington Quadrangle, and into the southeast part of the Kingfield Quadrangle. To the northeast from there, it is not persistantly sulfidic, but contains abundant zones of bedded gray sandstone and sulfidic slate. In the west part of the Dixfield Quadrangle, the Severy Hill Formation forms discontinuous patches stratigraphically above the Peru Formation. These are interpreted as due to lack of deposition, rather than to unconformity or erosion.

Saddleback Mountain Formation. This unit forms the bulk of the major syncline in the Dixfield Quadrangle. The most common rock type is cyclically bedded pelite and sandstone. Individual beds of the sequence range in thickness from 1 to 25 cm. The pelite is rich in muscovite, averaging 15 percent. Both graded-beds and cross-beds are abundant. Sections several meters thick, composed of homogenous pelite or sandstone are found throughout the unit. Commonly the sandstone is slightly calcareous and contains pods of calc-silicate. Many lenses of "ribbon limestone" and sulfidic rocks are present within this formation.

North from the Dixfield Quadrangle, the Saddleback Mountain Formation is traced across a fault and a granodiorite pluton into the

Bear Hill Formation of Moench. To the east and northeast from the Dixfield Quadrangle the Saddleback Mountain Formation is sandwiched by the sulfidic Severy Hill Formation on the southeast and by the sulfidic Temple Stream Formation on the northwest. This triple layer is traced as far as the Kennebec River in the Center of the Anson Formation. As in the case of the Thompson Hill Formation, the ratio of sandstone to pelite in the Saddleback Mountain Formation increases to the northeast. Excellent exposures of dominant sandstone with lenses of cyclically bedded sandstone and pelite can be seen in the Carrabassett River in North Anson.

The Saddleback Mountain Formation is assigned a Devonian age based on its lithologic similarity to the Seboomook Formation and the similarity of the Littleton trilogy (gneiss - calc-silicate (Boott) - well-bedded) with the Woodstock - Peru - Saddleback Mountain section.

Temple Stream Formation. This unit is composed of sulfidic, rusty-weathering quartzite, mica schist, and muscovite schist. As is the case of the Severy Hill to the northeast of the Dixfield Quadrangle, the rusty types are interbedded with gray sandstone.

Staples Pond Formation. This is the youngest unit under consideration. It is composed of thinly bedded to massive calcareous sandstone and minor slate. Like the Ludden Brook, it appears to be a southwestward extension of the "sandstone facies" which dominates the northeast.

The Facies Problem

It is notable in the above discussion of the stratigraphic units that the only formation which could be traced for a considerable distance to the northeast is the Ludden Brook Formation - a sandstone. Further, it has been repeatedly noted that there is a pronounced increase in the sandstone to pelite ratio of each formation toward the northeast. This is especially clear cut in the case of the Saddleback Mountain Formation.

The Saddleback Mountain Formation, sandwiched between two rusty units, is a cyclically bedded pelite and quartzite in the Dixfield and Farmington Quadrangles, whereas it is a sandstone in the Kingfield and Anson Quadrangles. One of the writers (KAP, who is currently mapping in the Kingfield Quadrangle) reports the following section in the Saddleback Mountain Formation at the southern edge of the Kingfield Quadrangle:

southwest — cyclically bedded slate and quartzite.

cyclically bedded rock with about 10 percent quartzite beds.

50 percent cyclically bedded rock and 50 percent quartzite grading into thin black slate.

Quartzite with some thin black slate and about 25 percent cyclically bedded rock.

northeast — Quartzite with minor black slate.

This section is 1/2 mile long and almost parallel to strike.

Other evidence that has a bearing on this problem is:

1. All the rusty units become thin and patchy towards the northeast.
2. Thousands of feet of the Buckfield Group apparently disappear.
3. The lower part of the Thompson Mountain becomes predominately a sandstone in the middle of the Farmington Quadrangle. 4. The Peru Formation changes from bedded calc-silicate and biotitic granulite in the eastern part of the Dixfield Quadrangle, to a calcareous sandstone in the Farmington Quadrangle.

It is clear to the writers, from the evidence cited and from four years of intermittent reconnaissance, that there is a general facies change from dominatly pelite in the southwest to dominantly sandstone in the northeast. We interpret the Ludden Brook and Staples Pond Formations as southwestward extensions of the "sandstone facies."

Based on reconnaissance, the writers feel that farther to the northeast the "sandstone facies" gives way to abundant pelite. This appears to take place in the Bingham, Kingsbury and Greenville Quadrangles.

The relationship of the "sandstone facies" to the rocks in the Buckfield and Dixfield Quadrangles is illustrated in Figure 2.

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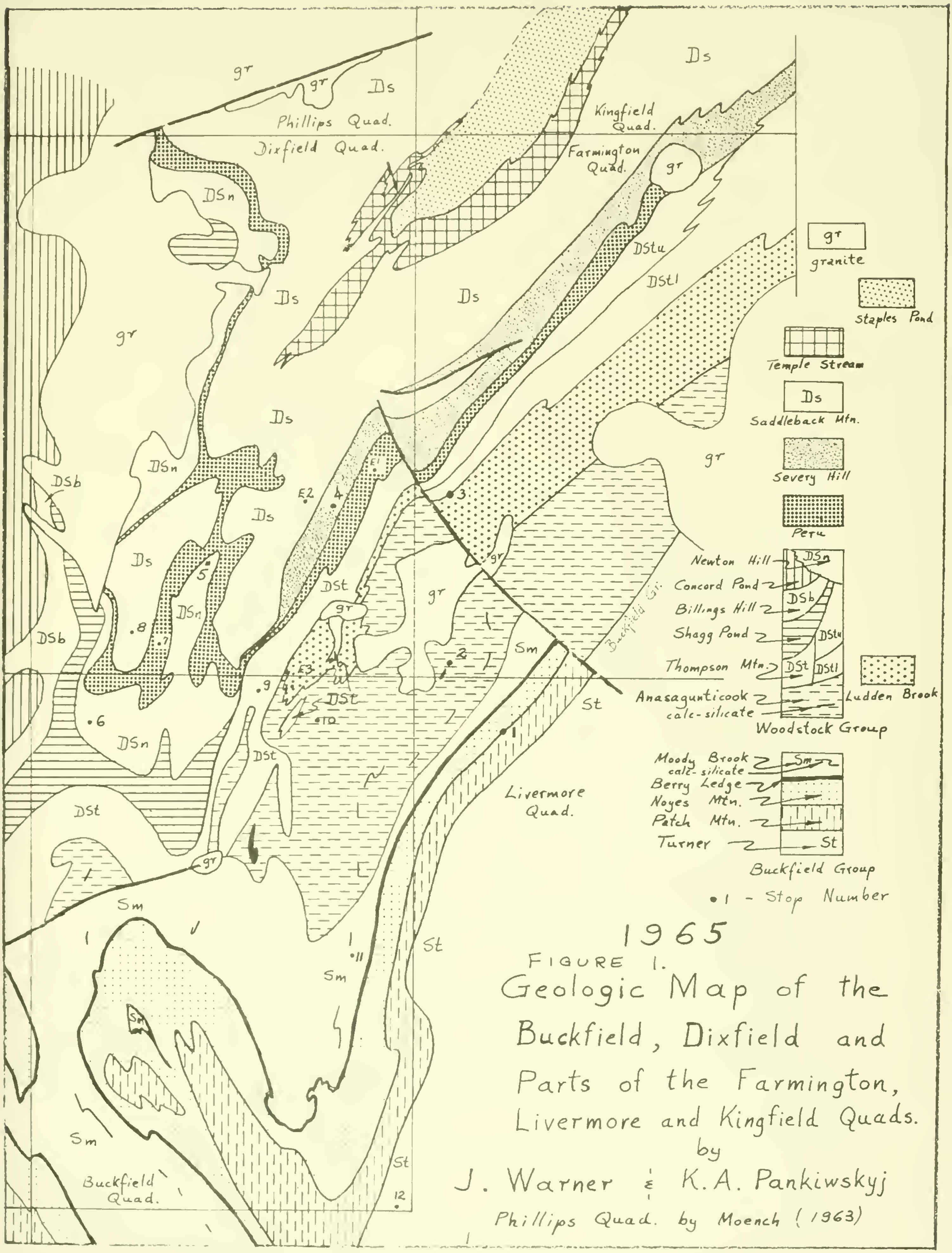

1965

FIGURE 1.

Geologic Map of the Buckfield, Dixfield and Parts of the Farmington, Livermore and Kingfield Quads.

by

J. Warner & K.A. Pankiwskyj

Phillips Quad. by Moench (1963)

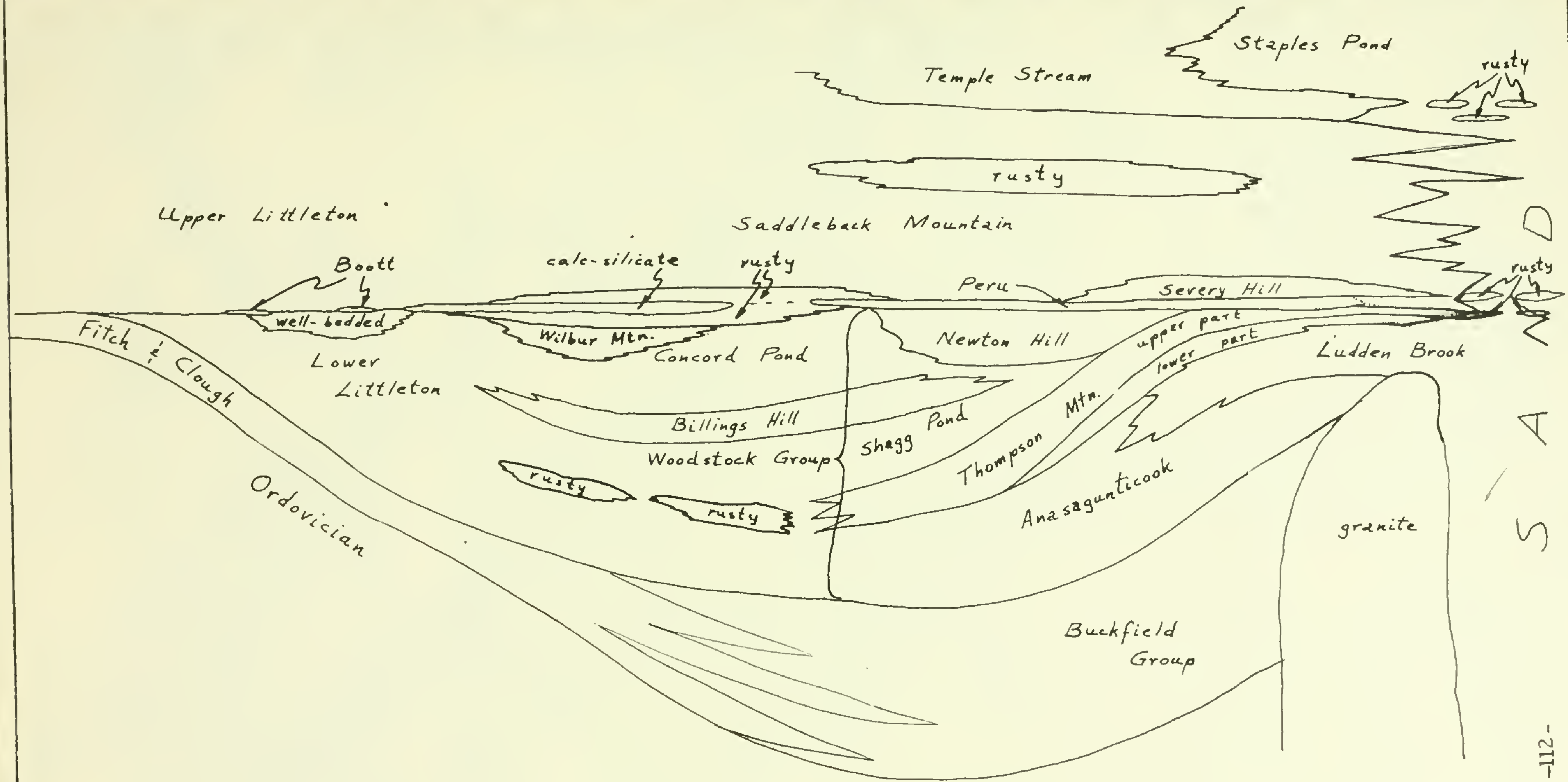

Figure 2 - Restored Cross-Section of the Silurian & Devonian Rocks in Northwestern Maine and Adjacent New Hampshire

Road Log

Meet at Livermore Falls, west side of Me. 4 bridge over Androscoggin River, at 9:15 A. M., Sunday, October 10, 1965. Suggest leave Brunswick at 0800 hours. Suggested route: U. S. 201 north through Topsham, left on Me. 196 through Lisbon Falls to Lewiston, cross Androscoggin River into Auburn on Me. 11, follow Me. 4 north from Auburn to Livermore Falls.

Topographic maps: Buckfield, Dixfield, Farmington, and Livermore.

0.0 Stop 1 Patch Mountain Formation and Noyes Mountain Formation.

Patch Mountain Formation in river below dam. Some geologists have seen primary tops right side up here. Crops on road are Noyes Mountain Formation. Several isoclinal folds are present in crop. Around corner to north is a weathered crop showing excellent sillimanite knots (maggots). Behind gray house to south is an exposure of the top beds of the Patch Mountain.

0.2 Cross bridge on Me. 4, left turn following Me. 4.

1.1 Crop of Berry Ledge Formation.

1.2 Several crops of Moody Brook Formation.

2.3 R. R. crossing.

2.6 Enter Farmington Quadrangle.

2.8 Turn left onto Me. 140.

3.0 Turn left onto paved road just short of white house, continue across two bridges.

3.3 Stop 2 Anasagunticook Formation.

Jay granite to east in river. Anasagunticook Formation on knob. Across bridge in a new R. R. cut to right are exposed Jay granite, pegmatite, and one of the lenses

of calc-silicate within the Anasagunticook Formation.

Turn around, retrace route toward Me. 4.

3.8 Turn left onto Me. 4 and Me. 17.

4.1 Power line.

4.7 Jay Hill Picnic area, view of Mount Blue.

6.8 Straight through N. Jay on Me. 4. Granite quarry 1/2 mile west of town.

9.2 Turn left about rotary onto U. S. 2.

9.6 Stop 3 Thompson Mountain Formation and Ludden Brook Formation.

East end of crop contains intricately, disharmonious folds and convolutions in the Ludden Brook Formation. Note the mineralogic zoning in the calc-silicate pods and beds. Center 15 feet of crop is a rusty-weathering "fault breccia" and intruded pegmatite. East end of crop contains mica-rich rocks of the lower part of the Thompson Mountain Formation. Several tight folds can be seen. Note the upgrade pseudomorths of muscovite+ biotite after staurolite.

9.7 Continue on U. S. 2 through yellow blinker. Crops of Thompson Mountain Formation.

10.0 Enter Dixfield Quadrangle.

10.5 View of Mount Blue.

11.6 Extra Stop 1 Peru Formation

Biotite granulite with scattered pods of calc-silicate.

13.7 Crops of Peru Formation.

14.2 Straight through East Dixfield on U. S. 2.

14.4 Stop 4 Severy Hill Formation

Park by Hall Farm. Crop is in brook at south end of field on south side of road. Walk on path through gate.

Thinly bedded Severy Hill Formation.

15.2 Crop of Saddleback Mountain Formation.

15.4 Extra Stop 2 Saddleback Mountain Formation.

Well developed cross- and graded-bedding indicate isoclinal folds.

17.9 Height of land.

20.0 Stop 5 Newton Hill Formation

Turn right on paved road, turn around, and park. Crop instream to south. NO HAMMERS PLEASE. This crop of Newton Hill is in the nose of a major anticline. It lies within 200 feet of the Peru Formation. Pods and beds of calc-silicate granulite of the upper part of this unit.

20.1 Turn right back onto U. S. 2 and Me. 17.

22.0 Newton Brook Picnic Area. Alternate lunch stop.

23.1 Crop of Peru Formation.

23.4 Turn right following U. S. 2 at lumber mill.

24.1 Crop of Saddleback Mountain Formation.

25.3 Entering Village of Dixfield - smell Rumford yet?

25.4 Crops from here to New Hampshire on U. S. 2 are all in the Woodstock Group.

26.3 Turn left over bridge crossing Androscoggin River.

26.6 Straight onto paved road. Cross Me. 108.

27.6 Pegmatite and Billings Hill Formation.

28.6 Enter Buckfield Quadrangle. View of Black Mountain.

29.7 Turn left onto paved road.

30.7 Turn right at four-corners onto dirt road.

31.4 Stop 6 Newton Hill Formation

This crop displays excellent graded bedding, axial plane foliation, and disharmonic folding.

LUNCH

31.6 Continue on dirt road until cemetery, make a U-turn. Good view of the Sugarloves to the north. Retrace route to four-corners.

32.4 Straight through four-corners.

32.7 View of Mount Zircon to west.

33.7 Turn right. Good view of Webb Valley and mountains in Rangeley region.

34.4 Turn left and stay on paved road until Me. 108 in Peru. Good view of Colonel Holman Ridge.

35.2 Enter Buckfield Quadrangle.

36.8 Turn left onto Me. 108.

37.1 Several crops of Newton Hill Formation.

37.5 Stop 7 Peru Formation

This crop is typical of the Peru Formation in the sillimanite zone: folded and injected by pegmatites. Tar cover of crop is not typical of the Peru Formation, but it is common of crops on Me. 108. Note that calc-silicate outcrops have a higher frequency of pegmatite than crops of other lithologies.

38.1 View of Whittemore Bluff across river - Saddleback Mountain Formation.

38.3 Stop 8 Saddleback Mountain Formation

Typical cyclically bedded pelite and quartzite, but with a greater than normal amount of calc-silicate pods and beds. There is a zone at the west end of the crop that has an unusually high concentration of calc-silicate.

39.8 Woodstock Group crops out from here to Rumford on Me. 108.

40.1 Turn right over bridge, retrace route through Dixfield to lumber mill at mile 23.4.

43.3 At lumber mill go straight (DO NOT FOLLOW U. S. 2) on paved road toward Canton Point.

44.8 Ledges in Newton Hill Formation.

45.2 Enter Buckfield Quadrangle. Crops of Newton Hill Formation.

46.8 Stop 9 Thompson Mountain Formation

Typical crop of this unit in the Buckfield Quadrangle and of the upper part of the unit in the Dixfield Quadrangle.

47.9 Extra Stop 3 Ludden Brook Formation

Type locality of this unit.

48.9 Stop 10 Anasagunticook Formation

This crop is typical of all the coarse-grained, gray-weathering, migmatitic schists (gneisses) in the Woodstock Group.

49.4 Caution- bad left turn in road.

50.7 Turn right at stop sign onto Me. 140.

51.4 Cross Androscoggin River on Me. 140.

53.1 Turn left onto Me. 108 in Canton.

53.2 Dixie to left.

53.8 Crops of Anasagunticook Formation with a lens of calc-silicate and injected with granite.

56.2 Stop 11 Moody Brook Formation

This and following crops are typical of this unit. The next crop is rich in the biotite quartzite phase of the unit.

56.6 Small crop to west of farmhouse on right is the Berry Ledge Formation (?).

56.7 Following crops are in the Noyes Mountain Formation.

58.0 Continue straight.

58.9 Continue right by joining Me. 4. From here to stop 12 we are in poorly outcropping belt of Patch Mountain Formation.

60.5 Boulders and crop of Patch Mountain Formation.

61.3 Straight through cross-road (Me. 219).

62.8 Crops of Noyes Mountain on hill to right.

64.8 Crops of Turner Formation.

67.6 Cross bridge over Nezinscot River at Turner.

68.1 Stop 12 Turner Formation

This is the oldest rock seen on this trip. The geology of the anticline between the Buckfield - Dixfield regions and the Waterville region is now being studied.

Suggested route to Boston - follow Me. 4 to Maine Turnpike Exit 12, 5 miles south of Auburn. Jimmy's Diner and Texaco in Auburn for good food and low gas prices.